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GENERAL SIR JOHN BURGOYNE, Bart., G.C.B., Inspector-General of Engineers, in the Chair.

TESTING ELECTRIC CABLES.

By C. W. SIEMENS, Esq., C.E., F.R.S.

Introduction.—On a former occasion, when I delivered a lecture in this Institution, on "Electric Telegraphs," I found that it was impossible, in the course of an hour, to go into the whole of the subject; and this evening I propose to confine your attention to "The Testing of Electric Cables."

Notwithstanding this limitation, I find that I should not nearly be able to exhaust my subject or to give you the proofs of the different problems involved. I shall, however, endéavour to give a general outline of the principles involved in testing electric cables; and also show you the *modus operandi* by which the more important of these tests are carried into effect. It is unnecessary for me to enlarge on the importance of electrical tests; I would only call to your mind that in the case of an Atlantic cable, a single flaw—a microscopic defect—would vitiate the whole undertaking. But I also hope to be able to prove to you that by a proper system of electrical testing, the chances of such a flaw remaining unobserved, are infinitely small.

General Laws.—In dealing with the subject, we have to operate chiefly with one of the forces in nature, that is the "electromotive force." We are taught, however, that the forces of nature, such as heat, light, electricity, and chemical action, are reducible to one

and the same fundamental principle—that is, "mass in motion." If I take any weight, say one pound, and raise it one foot high, I cause a tension between this substance and the table, or the earth beneath it, which tension will call this weight back to the table through the space of one foot, with a force of one pound, and the power here represented is the foot-pound or unit of force. In electrical science we have another kind of tension, which is not gravity, but electro-motive force. We have in each of these glass jars, a porous jar containing proto-sulphate of mercury. This proto-sulphate of mercury is composed of sulphuric acid and oxide of mercury, and the oxide of mercury of oxygen and metallic mercury. Inside this pot amidst photo-sulphate of mercury is carbon, and outside the porous pot is zinc. Now, zinc has a great affinity for oxygen, whereas carbon has, at low temperatures, a very slight affinity for oxygen. The consequence is that the zinc wants to combine with the oxygen and set the mercury free. The sulphuric acid present is quite ready to take up the oxide of zinc as soon as it is formed, and aids the tendency of the zinc to separate the oxygen from the salt. A tension is produced which results in chemical action and in motion of the particles acted upon, which latter manifests itself either as heat or, if the conditions admit of it, as electricity. The chief condition necessary to produce the electric current consists of a metallic connection between the carbon and the zinc, and it is within this metallic-connecting wire that the electromotive force becomes manifest and applicable for our purposes.

But it is quite permissible to represent electromotive force by gravitation. I have here a diagram (Plate XXII., Fig. 1) in which the height of the liquid in a tube is to represent electromotive force or the height of this column represents the attraction of the zinc for the oxygen. If to one element I add a second similar element, I produce the same effect as adding to one column another similar column; I super-add one tension to another, or I double my electromotive force.

Now, the liquid-column, shown in the diagram representing the electromotive force, would discharge itself through a narrow pipe, with a velocity depending upon the height of column, on the one hand, and upon the frictional resistance or obstruction offered to the discharge of liquid on the other hand. The analogous obstruction offered to the electric current within a conductor we call electrical resistance. If the pipe is of a certain length, say one metre, and of a certain size, say of one square millimetre sectional area, we may call the obstruction which it offers to the flow of liquid a unit measure. If we were to double the length of the pipe, we should have exactly double the resistance; and if we neglected the influence of inertia, only half the amount of liquid would flow in a given time. By increasing the length of pipe indefinitely, we shall be able to ascertain its length in measuring the delivery at the outlet. This is accomplished in dealing with electrical resistances by means of the electrical balance which I shall describe presently.

Another important point for us to fix, before entering upon the real subject of the evening, is that of charge, or electrical induction. If the liquid, represented in the diagram, was suddenly let loose upon the

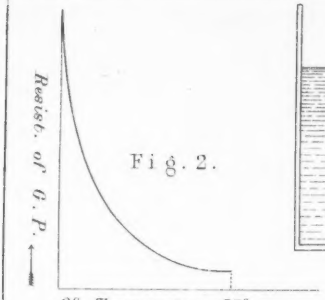


Fig. 2.

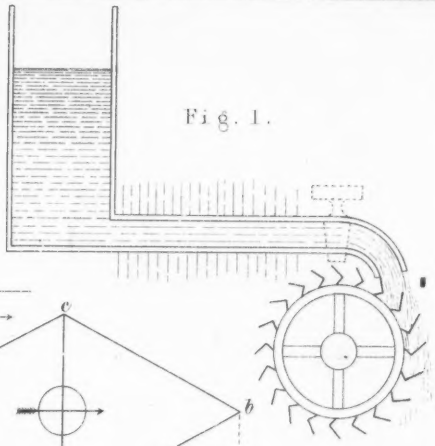


Fig. 1.

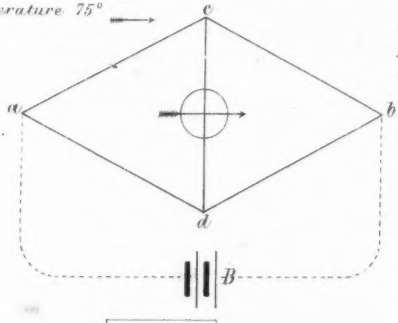


Fig. 3.

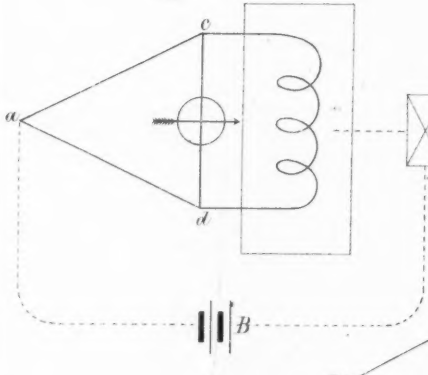


Fig. 4.

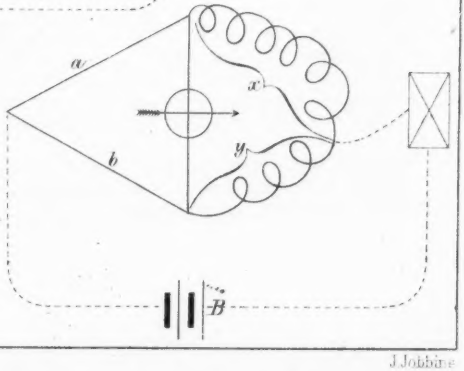


Fig. 5.

pipe, it would not flow from it until the pipe itself was filled; and if the sides of the pipe were composed of a porous substance, then its pores must also be filled beforehand; but if we suppose that this substance, besides being porous, is elastic, that is to say, composed of cells containing air, then the amount of liquid that would have to be absorbed into the walls of the pipe would be proportionate to the height of liquid, or to the electromotive force, as we should call it.

In these illustrations, analogous laws are involved to those which we have to deal with in electricity. I must mention, however, another. If the porous substance composing the pipe allowed of a certain amount of liquid to ooze out on all sides, we should then, not only have to deal with the liquid flowing out at the other end, but also with this leakage, which leakage we may regard as a separate discharge, bearing a certain proportion of the principal discharge, or as offering a certain proportionate resistance to the flow of the liquid. By increasing the length of the tube, the leakage will increase or its resistance to leakage will diminish in the same proportion.

Now, if at the outlet end we had a water-wheel, and made that water-wheel turn by the flow of the liquid, we should then have a case analogous to working an electrical instrument at the end of our line, and it is at once apparent that we should endeavour to lose as little of our current on the road as possible, either by conduction, or by induction, or by absorption into the material composing the pipe, in order that we may obtain the greatest possible effect from a given source of power and a given size of conductor. This illustration serves to bring home to our minds the nature of the forces and resisting influences which we have to deal with in submarine telegraphy.

At the root of all electrical measurement is what is called Ohm's law, which says that the current, or the amount of the flow, is equal to the electromotive force divided by the resistance. That is a law which applies not only to electricity, but also to heat and other forces. It stands to reason that the amount of electricity flowing through a conductor is as the electromotive force (or the height of the column), and, inversely, as the resistance. All substances do not, however, offer the same resistance to the electric current. If this pipe was rough in the inside it would offer greater resistance to the flow of water than it would if it was smooth. So, also, if we have a conductor of one metal, such as iron, we find greater resistance than when we have the same length, the same area of conductor of another kind, such as copper.

That brings us to the measurement of electrical resistances. There is a table here showing the conductivity of different metals, which vary in an extraordinary ratio. Thus, pure copper conducts fifty-five times better than mercury; whereas, the copper of commerce very often conducts only about five or six times more than mercury.

Measure of Electrical Resistance.—In order to measure resistance, we must have a measure or unit of resistance, just as much as, in order to weigh a substance, we must have a unit weight, such as the pound or kilogramme. Several units have from time to time been proposed. Formerly the mile of iron or copper wire, or, in France, the kilometre of iron wire, of a certain section,

was taken to represent the unit of resistance, but it is evident from what I have just stated that these are very vague measures. A slight variation in the constitution of the metal, or in its admixtures, would vary the value of a mile of wire between very wide limits. It was at the time when electrical tests assumed a practical and serious shape that my brother, Dr. Werner Siemens, proposed his mercury unit; that is, the resistance offered by one metre length of mercury enclosed in a tube of one square millimetre sectional area at the freezing-point of water. This unit has been generally used in cable-testing up to this time. But, at present, another unit is proposed, the British Association unit, which is derived from Weber's absolute unit of electrical force. It is difficult to explain correctly what that means; but the following may serve to convey the general idea:—If I have a loop of wire of a certain length, and turn it suddenly, with respect to the magnetic axis of the earth through 90°, I develope in this wire a certain current which, if it is made to act upon the needle of a galvanometer produces a certain deflection. The force thus set up by this motion, Weber calls the absolute unit of electrical magnitude; and the resistance which is set up in the loop of wire of given quality and dimensions he calls the unit of resistance. Now, ten millions of these units of resistance would form the unit of resistance proposed by the British Association Committee. This unit would have certain ulterior advantages, being referable to a unit of force; but its production is attended with considerable difficulty, which leaves reasonable room for doubt, whether future determinations may not materially modify its value. At present the material unit of a certain amount of mercury, which being a liquid is not subject to differences of temper, contained in a certain tube appears to be more certain, it differs only about 4½ per cent. from the British Association unit, and it has this advantage—it is largely used.

Measure of Charge.—In addition to the unit of resistance, we have to determine the unit of charge, or unit capacity for static electricity, which may be defined as follows: If I have one round plate of metal of any given size, and oppose to it another plate of metal of the same size, approaching them to the distance equal to their own diameter, I have a unit measure of capacity for electricity. I may take these plates as large as I like, or as small as I like; so long as I make the distance equal to the diameter, the amount of electrical charge contained by such arrangement is always the same, taking atmospheric air to be the intervening medium in every case.

Effect of Temperature.—We have next to consider the effect of temperature upon a conductor. We have hitherto assumed that a wire of a certain length, of a certain diameter, of a given material, produced a given resistance. That is only true as long as the temperature remains the same; but with change of temperature, the resistance also changes in a fixed ratio, which is perfectly well ascertained as regards metallic conductors. Therefore, if we want to compare electrical tests, we must either make the actual measurement at a fixed temperature, or we must introduce a calculation by which we reduce the values to a standard temperature. With regard to

metals, the ratio in which temperature affects conductivity, or electrical resistance, is a very simple one; but it is very different with the substances which we call dielectrics, or insulators. There are no such things as absolute insulators; but the insulator which we mostly apply, namely, gutta-percha, increases in its conductivity with increase of temperature in a very rapid ratio, which may be represented by an ascending hyperbolic curve (whereas the ratio applicable to the metals is represented by a straight, descending line—see Diagram No. 2). A precise knowledge of these ratios is of great importance to the art of testing cables.

Wheatstone's Balance.—In measuring the resistance of metal-conductors, we generally employ a method which is based upon the Wheatstone's diagram or balance. We weigh one resistance against another known resistance, and thereby determine its value. I have Wheatstone's diagram here, which is also represented by a diagram (fig. 3), but which may be seen in actual operation. If we send the current of the battery, B, into this point of juncture, *a*, the current must flow in the two directions, constituting the branches of the diagram, which branches re-unite at the point *b*, whence the current is brought back to the battery at the opposite pole from whence it proceeded. The current will, according to Ohm's law, divide itself between two conductors, inversely as their conductivity. If the arms, *a c* and *a d*, are equal in resistance, and the two branches, *b c* and *b d*, are also made equal, then there would be as much current pass the one way as the other; and no current will pass through a channel which connects the two points, *c* and *d*. In this cross channel there is a delicate galvanometer, the needle of which would deflect with any passage of current crossways. But suppose I were to make this resistance, *b d*, very great as compared with the resistance, *b c*, then the current flowing through the branch, *a d*, could not all of it proceed through *d b*, but would divide itself again, part of it passing through the cross branch, *c d*, and the inferior resistance, *b c*, deflecting the galvanic needle. If we now increase the resistance of *b c* until it equals *b d*, then the two branches will again pass an equal amount of current, and no deflection of the needle will occur.

If *b c* be an unknown resistance, and *b d* is one which we can alter *ad libitum* by putting in or taking out stoppers, representing each a known resistance, we can so adjust the latter that upon the application of current no deflection takes place, in which case the one must be the exact measure of the other. That is one method of testing which we employ. I have here, on this table, a complete testing board, which has been taken out of actual use only to-day, in order to be reinstated to-morrow morning, which we employ for testing our cables, and in which as many as twelve different methods of testing are contained. By simply altering these stoppers, we can use the one method or the other. I may here state that this apparatus, in order to be efficient, must be constructed with extreme care; it is a matter involving considerable mechanical skill to make a coil representing an exact amount of resistance; and it also requires considerable skill to make these

connections so that there are no false currents or loss, in order to get natural and correct readings.

These different methods I shall endeavour to pass in review.

There is the direct method which I have just alluded to. Now, in order to measure with the greatest amount of accuracy, it is natural that the two channels through which the electricity flows into the balance should be about equal. If you wanted to weigh fairly, you would make the two beams of the balance about equal, for if one arm of the balance were short, and the other long, you would not weigh at this short end with the same degree of nicety. In the case of electricity another evil arises, that the current, dividing itself unequally between the long arm and the short arm, would heat the short arm; therefore, we are limited in the use of Wheatstone's diagram to a certain range of resistance. We can produce, artificially, the resistance of a thousand units; and, therefore, can compare directly as though I was weighing by equal arms, resistance to that amount. If a greater amount of resistance is to be measured, I can help myself by altering the two first branches of the resistance, which represent the arms of the balance. If, by means of stoppers, I make the resistance of one arm one hundred times greater than the resistance of the other arm, then the resistance I am seeking will be one hundred times greater than the other, which I shall have to establish by stoppering. On the other hand, if we want to measure very accurately a small resistance, we alter the comparative resistances in the other sense, making the stoppered value represent ten as a hundred times the resistance to be measured. When we come, however, to measure the leakage through a mile of cable, we would find not ten thousand units, or one hundred thousand units, we would find one hundred millions, or even as much as five hundred million units of resistance.

Sine Method.—In such a case we must resort to a totally different method, which we call the sine method. Here is an instrument which is used for that purpose, being a very delicate sine galvanometer. If a current flows through the coils of this instrument, deflection of the needle takes place; and this deflection increases with the current in the ratio of the sine of the angle, provided you turn the instrument upon its vertical axis through the angle of deflection. This needle being suspended by a silk thread, and being made very astatic, an exceedingly small amount of electricity flowing through, will produce notable deflection. I have to connect my wire in this way, that I bring my battery to one end of the copper conductor enclosed in the insulating tube of gutta-percha or india-rubber, the other end being sealed, and the external covering, or the water in which the conductor is immersed, in connection with the other pole of the battery, including the galvanometer coil into the circuit. We then get a deflection, and from this deflection we calculate the resistance by the simple formula of the resistance being equal to the sine of the angle, divided by the sine of the angle of deflection, which would be produced by an unit of electro-motive force, or by one element upon the same needle, multiplied by the number of elements employed, or

$$R = n \frac{\text{Sin } \alpha}{\text{Sin } \beta}.$$

The deflection which is produced by an element upon the needle has to be determined frequently in testing by this method, and is called the constant of the instrument.

This method is not so simple as the Wheatstone method, where we compare simply one resistance with another; it has, however, the advantage of greater sensitiveness, being much improved in this respect by the application of Professor Thomson's reflecting galvanometer, which with its mirror attached to an extremely delicate needle, reflects a ray of light upon a large scale, and enables us to read with clearness very small angles. For very small angles, as you are aware, the sine may be taken for the angle itself, and therefore, in measuring with this instrument, instead of taking the sines of the angle, we take the simple deflection, and thus save calculation.

Differential Method.—Within the last twelvemonth, we have divised and introduced into practice at the Charlton works, another method of measuring resistances, in which neither artificial resistances nor a sine galvanometer are used, and which recommends itself by its extreme facility of operation. The instrument employed consists of a very delicate galvanometer, and of a coil put separately upon a screw carriage, which latter acts upon the same needle under the influence of a constant current. The resistance to be measured is put into the galvanometer circuit with a battery of fifty cells, to produce the current. We connect a second battery to the balancing coil, which is mounted on a slide, that admits of being moved to and fro. It is evident that if I know the effect that would be produced by one cell on the moveable coil, and of a hundred cells on the stationary or galvanometer coil in balancing each other upon the instrument itself, I shall be able to judge the effect also of a larger resistance in the circuit of the latter. For instance, if I have in the galvanometer circuit a resistance of one million units, I know that in order to balance the needle on the galvanometer, I must screw the moveable coil to a certain point on the scale; then, by increasing that resistance, I must diminish the relative effect of the moveable coil, in order to maintain the needle in balance by moving to a point which can be fixed beforehand by calculation, or which may easily be tabulated from a series of observations in dealing with known resistances. In working with this instrument the unknown resistance is put into the galvanometer circuit, and the screw of the moveable resistance is worked to and fro, until the needle has assumed its zero position, when in reading upon the scale the divisions, I find at once in my table the amount of resistance in units which I wish to measure. Such an instrument is particularly useful where you want to operate quickly, as you do on board ship. In paying out cable, it is of the utmost importance that, when a fault goes overboard, you should at once be able to determine the magnitude of that fault; and this can be accomplished in much shorter time with this instrument than with the instruments we have formerly employed.

Discharge Method.—Another method of measuring a very high resistance is by natural discharge. If we have only a short and highly insulated wire, and charge the same with electricity, the external surface being connected to earth, we shall find that a natural discharge takes place in time, which latter varies according to the insulating property of the covering. This diminution will go on at a very uniform rate. If I employ a very high electro-motive force, say one hundred cells, I produce a high state of tension; this tension produces a comparatively rapid discharge, and at the end of a given time—say in one minute, it will have descended to half that charge. If, on the other hand, we employ a weak current, or small electromotive force, we shall have only a small quantity of electricity to discharge, and it will be found that this charge will be reduced to one-half in precisely the same time. In employing this method we are perfectly independent of the amount of battery power employed, but in taking the charge we must note the time; in connecting now the wire with an electrometer, we shall have to watch this electrometer in order to note when this charge has dropped down to half charge. The time of discharge gives us a direct comparison between insulators, although it does not give us their resistance in units. Therefore, this method only serves to determine the general quality of an insulating material, but is inapplicable for measuring submarine cables.

Charge in Cables.—We have now gone through the different methods of testing, and of determining resistances. We come to another branch of the subject—that of determining the charge or lateral induction. If a current flows into an insulated wire, the current does not pass through it without electrifying the insulating substance surrounding it. Part of the current leaks through the insulating material; but a larger amount of it is found there remaining, as it is in a Leyden jar, and forms what is called static electricity. It is evident that before a current can pass through the cable from one end to another, it must charge the whole length of its insulating covering; in fact, the gutta-percha surrounding this wire acts the same as the glass of a Leyden jar. We may consider a long submarine cable like an infinite succession of Leyden jars, which have to be charged one after the other before the electricity can flow out and produce its effect at the extreme end. It is evident that this retardation or this absorption of current should be made as small as possible, in order that each current may as soon as possible arrive at the other end; but we find that different substances absorb different amounts of electricity in charge. Thus india-rubber absorbs only three-fourths of what gutta-percha would absorb, and is in this respect the preferable material to use. But, independently of this consideration, we sometimes want to know the amount of charge which a cable will take, in order to determine by it, its length. If, for instance, we know our insulating material, the size of our conductor, and of the insulated wire, we can tell beforehand what will be the amount of charge in a given length of cable. We measure the charge by the deflection of a galvanometer, and in this way by reading the angle of a single deflection, in putting the battery to the cable, we

find the charge K to be equal to the sine of half the angle of deflection divided by the electro-motive force, or the number of cells employed, or, in mathematical language, we have

$$K = \frac{\text{Sin } \frac{a}{2}}{n}$$

which formula represents the capacity of a cable for the unit of electromotive force.

This is one method of determining the charge, or rather the capacity, of a cable.

Another method is by the employment of an instrument which we call the "*wippe.*" It being very difficult to read the sudden deflection of a needle when connection is made with the battery, we substitute by this improved method the constant deflection of that needle. The instrument by which we accomplish this object, and which is placed upon the table, consists of an electrical appliance for producing uniform rotation of a spindle, by means of which connection is made, at rapid intervals, alternately between the cable to be measured and the battery, on the one hand, and the earth on the other hand, producing a regulated succession of charges and discharges. Suppose I make one hundred, or say twenty, charges in a second, and twenty discharges. All these charges go through my instrument in rapid succession, and the needle has not time between impulse and impulse to return to zero, but it will subside into a medium position, which we can examine at our leisure. The charge in this case is not proportionate to the sine of half the angle, but to the sine of the angle of deflection itself. In like manner the instrument enables us to measure the discharges of the cable to earth, allowing the charges to go into the cable direct. We have thus a ready means of carefully examining the capacity of any given cable. Though I could put this instrument now to work, it could only be seen by two or three gentlemen, and even those would require more leisure than we could afford them at present, in order to satisfy them of the result; these are, indeed, not experiments for a lecture-room, but for the study.

Order of Tests.—I think I have passed through all the principal modes of measuring resistance and charge. I should say a few words now about their application in practice. We have to test the cable in all its stages of progress, in order to guard against the possibility of a fault. Commencing at the insulating works, or say at the gutta-percha works, we have first to examine the wire which is proposed to be covered. As I have shown at the beginning of the lecture, the conductivity of copper wire varies between wide limits; and unless great care is used, unless every portion of the wire is carefully examined, we might lose enormously in conductivity. It will be seen at once of what importance conductivity is, if we consider that the charge, say of the Atlantic cable, is a fixed quantity, which has to be furnished before the current can make its appearance at the further end; and that, in filling this large jar, we are limited only by the conductivity of the insulated wire, which allows the

electric current to flow in. If the conductivity of that wire could be doubled from what it is at present, we should, in exactly half the time, accomplish our end, or, in other words, we should double our rate of speaking. If, on the other hand, we should allow ordinary copper of commerce to be employed which had a conductivity under twenty-five times that of mercury, whereas we can practically obtain wire conducting fifty times better, we should speak with only half the velocity which we ought to have attained to. Therefore, as the conductivity increases, so the velocity of transmission will also increase, hence the importance of using the very best copper for the purpose.

Having satisfied ourselves upon that point, the wire is handed over to the manufacturer to be covered. It is thereupon tested for insulation. But the electrical resistance of gutta-percha varies with temperature, and in order to get proper comparative tests, we must know the exact temperature of the wire. For this purpose cisterns were arranged, at my suggestion, in testing the Malta-Alexandria core, in which each coil of wire, as it is covered, is soaked for twenty-four hours, the water being maintained at a standard temperature of 75°. The resistance of the insulator, which we obtain at the standard temperature, may be directly compared with the resistance which we have observed in another coil to determine their relative perfection. The coil is next put under great hydrostatic pressure in Reid's pressure-tank. Under this pressure a curious phenomenon appears, namely, the electrical resistance of gutta-percha increases in a fixed ratio. Experiments which I had occasion to make, and which went up to a pressure of 300 atmospheres, showed that the increase due to that amount of pressure, three-folds the electrical resistance. That is to say, if we had electrical resistance of one hundred million of units at atmospheric pressure, by increasing the pressure to 300 atmospheres, we increase the resistance to three hundred millions of units. The moment the pressure is released, the pressure falls rapidly to its original amount. At the bottom of the Atlantic there is a pressure of nearly 300 atmospheres; it will therefore be found that when a good cable is submerged, the electrical resistance or its insulator must increase permanently three-fold; it must further increase on account of the lowness of the temperature at the bottom. For this double reason the insulating conductor is under the most favourable circumstances that could be imagined, when submerged in a deep ocean. This increase of insulation under great hydrostatic pressure does not affect all materials alike. India-rubber-covered wire, when subjected to the same pressure of 300 atmospheres, decreased in insulation, although it immediately resumed its original high degree when the pressure was released. The change of conductivity by pressure is therefore not reducible to any general law, but applies to each individual substance differently, but it is very important to know in dealing with cables, what changes we may have to expect in submerging them.

Having tested the conductor at the insulating works, it is transferred to the sheathing works, where it is again tested, both during the time of its being covered, and afterwards when it is put into tanks. The

usual way of testing it while it is being covered, is to put the conductor into circuit with a battery and an alarum, which latter is made to ring the moment the continuity is broken. Mr. Schwendler, an electrician connected with me, has lately devised a plan by which a continued test for insulation may be applied, and by which an alarum is made to sound the moment the insulation is injured. This is of more importance than the mere continuity test, inasmuch as in the process of covering a cable with iron the soft gutta-percha, or india-rubber, is far more likely to be injured than the conductor itself.

I may also mention here another investigation which has lately been made by Mr. Schwendler, which is to determine the best resistance, or the resistance producing the maximum of magnetic moment in the galvanometer employed in testing with the Wheatstone diagram. I have in the early part of the lecture said that in order to weigh accurately with Wheatstone's diagram, the branches of the system should be as nearly as possible equal. But no rule has as yet been established to determine, if you have to deal with resistances of a certain average value, what resistance on the galvanometer would produce the maximum effect. Mr. Schwendler finds that the resistance of the galvanometer should be the same as that of each of the branches of the Wheatstone diagram, to produce the most delicate reading.

Testing Joints.—We next come to a branch of testing which we have not referred to as yet; that is, testing the joints. The insulated conductor is sent from the insulating works in lengths of one knot; these have to be joined together before the cable is sheathed, and in making these joints, extreme care has to be used to prevent flaws. The old way of testing joints was to put the freshly made joint into water, to see whether, by doing so, the general insulation of the cable was decreased. But if the cable is very long, then the general decrease of insulation upon it, by even a defective joint is but small. In joining two ends of a cable together, of one mile each, presenting each the enormous resistance of say two hundred millions of units, the total resistance would be seriously affected by a joint which was slightly defective, offering a resistance of say four hundred millions of units; but as the length of the cable increases, its total insulation-resistance must go down; when its length reaches one hundred miles, the insulation would be measured by two millions of units, in which case the fault of four hundred millions would be inappreciable by the instrument. I think Mr. Whitehouse first suggested to measure the leakage separately, by putting the joint into an insulating trough of water, which was connected with one pole of a powerful battery, the second pole of which was connected to the cable with a galvanometer in the circuit to detect leakage. Mr. Latimer Clarke has very much improved upon that method, in connecting the insulated bath with a condenser, which condenser charges itself gradually with the leakage through the joint, and is discharged at a certain interval through the measuring instrument. There is only one objection to the latter method, which is, that the condenser itself leaks. It is indeed exceedingly difficult to get a condenser which is as perfectly insulated as the copper wire within a cable. Therefore the charge

you get in the condenser is not absolutely the expression of the amount of electricity that leaks through the joint.

It is true that the charge accumulating in even an imperfect condenser must always be proportionate to the electricity flowing into it, the leakage itself being proportionate to the accumulation. Still, this would be supposing that the condenser itself did not vary in its condition by changes of temperature or by moisture. Considering the difficulty of obtaining a permanent condenser, I prefer to employ another method, which is represented in fig. 4. Between the two permanent branches of a Wheatstone diagram a delicate galvanometer is placed, and the cable is inserted between the open end of these resistances or branches. The cable, being in a water-tank, is connected on its outside with the battery, the second pole of which is joined to the resistance-coils. Now, if the cable is mechanically perfect, the insulation-resistance must be everywhere the same along its whole length, and this being the case, there must be as much electricity flowing from the battery through the two resistances, and through every portion of the covering of the cable to earth; the leakage from the cable would, in fact, produce the same effect as one collective leakage at the exact middle of that cable. If there should not be that perfect balance, but if there was a faulty joint at a point near one end of the cable, then the discharge of the battery current to earth would gravitate to this point, and that branch of the balanced resistances near at hand would pass more current than the other branch. The result would be that the needle, in the connecting link or bridge, would be deflected. Now, if an artificial resistance were inserted at the end of the balanced resistance, nearest the fault, this could be so regulated as to re-establish the balance of currents on the galvanometer, and we should get an indication of the importance of that fault. This method is exceedingly sensitive, and a simple means of furnishing a continued verification of the normal condition of a cable in course of manufacture. The slightest inequality between the sides will tip the needle over to one side or the other, as may be illustrated by the diagram before us, in which hydrostatic pressure is again substituted for electrical force. If we take a flat bar of wood, accurately balanced upon pivots in the middle, and bring it under a general rain, then the rain falling down equally upon it, will keep it perfectly in balance, because it will fall everywhere alike. But if at a point near one end there should be an extra amount of rain-fall, this would immediately cause the bar to tip, for the same reason that the electrical balance tips under the influence of the extra leakage of a faulty joint.

Testing on board Ship.—Having tested the cable at the insulating and at the sheathing works, we have now to coil it on board ship into tanks filled with water, where it is again subjected to daily electrical tests until it is finally submerged. It has occurred frequently that the cable in running overboard has suddenly shown a fault, and it is the duty of the electrician instantly to arrest the operation. The paying out apparatus used on board ship must be so arranged, that with the least delay of time, the cable may be hauled back in order that the fault, which in the meantime should

be accurately determined by the electrician, may be seen to, the moment it comes on board, and the operation continued with the least possible delay. Formerly, no tanks were used on board ship; the cable was dry on board, and it was impossible to know whether it was defective or not, until it was submerged. Since the manufacture of the Malta and Alexandria cable, when I had it in my power to apply water-tight tanks for the first time, these tanks have been invariably adopted, and the operation of paying out rendered more safe in consequence; the chance of any fault going overboard should indeed be exceedingly small. Before the water-tight tanks were used, the method of testing a cable during submergence consisted of putting on the land station a clock, which made certain electric connection, at given intervals of time, in the course of an hour; it made connection of the cable with the earth, with the receiving instrument and for insulation at preconcerted intervals. On board ship, the electrician would, during these intervals, be prepared to test for insulation or for continuity, or to give the necessary instructions to land. It is desirable to test during the paying out as much as possible for insulation, because the important point is to have insulation perfect, the land clock was therefore so arranged, that about three-fourths of the whole time was reserved for insulation tests. At present, when a cable passes from the water in the tank into the sea, it is not so necessary to introduce these various tests. A method has lately been suggested by Mr. Willoughby Smith, which is very promising, of superseding the former ship tests. This consists in having always insulation tests upon the cable; and to connect at the land end a length of insulated wire or condenser to the cable, which is in connection with a very delicate galvanometer, such as a Thomson's galvanometer. If, now the cable which remains always charged, is put to battery on board ship, an extra charge will flow in at the condenser, and affect the galvanometer at the land end, enabling him to speak to land while the insulation test continues—not through instruments, it is true, but through a delicate galvanometer, which may, however, suffice for conveying the necessary instructions. I am not quite satisfied in my own mind whether this method would work with sufficient distinctness to be practicable in paying out a very long cable; but for a short cable I am quite certain that it would work well. It is one of those methods which, although not yet practically tested, I have thought right to mention.

Testing for Faults.—If, in paying out, a fault appears within a short distance of the ship, then we could pull back and remedy the fault, and go on. But, unfortunately, it happens sometimes that a fault appears after the cable is laid. If it appears immediately after the cable is laid, it must be a rupture, or the cable has been very badly manufactured; but in course of time, when the cable has been exposed to chafing near shore, or to an accident, faults will appear, and we must be prepared with methods to determine the position of such faults, with a view to their repair. This is one of the most important and most beautiful branches of electrical testing. There are different conditions and circumstances to be observed. If we have, first of all,

a fault in a cable of which both ends are accessible, as would be the case if the cable contained two conductors, and in uniting the two conductors into one enabling us to operate upon both sides from the fault, we would then be in the condition as represented by diagram fig 5. We then get the determination of the position of the fault by finding two equations, the one giving the resistance of the whole conductor—

$$l = x + y$$

and the other giving the proportion between x and y, namely—

$$a : b = x : y$$

and in developing x and y from these, we have—

$$x = \frac{a\,l}{a + b}$$

$$\text{and } y = \frac{b\,l}{a + b}$$

This method is the best, being the only one in which the resistance of the fault is wholly eliminated.

Another condition is, in dealing with a single cable, when the fault still permits us to speak through from end to end. In that case we shall have to measure the insulation resistance, and get our correspondent at the other end to do the same, and communicate the result through the cable. We embody these results in two formulas as before, from which we eliminate the resistance of the fault, and establish the numerical relation between x and y, representing the resistances on both sides of the fault, for which we may put lengths of cable, supposing the conductor to be uniform.

Another description of fault where it is more difficult to operate is, when the cable is ruptured altogether, and you can consequently no longer speak through it. In that case we have to deal with the resistance of the cable and the resistance of the fault, or place of contact between the conductor and the sea, which you cannot eliminate. We can, however, approximately determine the resistance due to the fault in observing the amount of polarisation produced by a current of a certain duration. If there is much copper exposed, there will be much polarisation, and, therefore, little resistance in the fault itself, and *vice versâ*. And thus by careful comparison and analysis we can approximately determine the resistance of the fault and of the remaining resistance which determines the position of the fault.

Another case arises if a cable is ruptured, but the gutta-percha completely overlaps, and insulates partially, the end of the broken wire. In that case we operate by measuring the capacity for charge of the cable, in connecting the cable with a powerful battery for a moment, and suddenly disconnecting it and making connection to earth through a galvanometer, when the needle is sent over to a certain angle; and from that angle of deflection we can calculate, as before described, the importance or capacity of the Leyden jar formed by the cable to the point of discontinuity. It is true that there is leak-

age; but by measuring the charges, and also the discharges, we find, in the difference, an expression for this leakage, and we can, by taking the mean between the two, determine the exact capacity of the cable remaining, and, therefore, also its length, having determined its specific capacity beforehand.

Another case, an analogous one, which occurs sometimes, is that the copper wire alone is separated, but the gutta-percha or other insulating covering remains intact. There we have the jar without any leakage at the end, and we can by our formula determine the importance of this jar as compared with the unit jar of capacity. Having thus determined the position of a fault in a cable under different circumstances, the vessel proceeds to the spot, takes it up, repairs it, and puts the cable back in its normal condition.

Conclusion.—Having now conducted you somewhat hurriedly over the field of electrical tests, I hope I have succeeded in satisfying your minds that the application of a well arranged system of tests is not only most desirable, but absolutely essential for the success of submarine cables. I would go further, and assert that a fault should never occur during the laying of a cable, for, however microscopic a fault may be, it ought to be detected before it goes overboard, and a good sheathing should secure the core against mechanical injury. When I addressed you before on the subject of deep-sea telegraphs, the "Great Eastern" was on the point of leaving these shores. I then expressed my confidence in the insulation of the cable, but some doubt as regards the efficiency of the outer covering. The failure which has since unfortunately occurred has not diminished my confidence in the insulated conductor, and in the eventual success of the undertaking, if only the outer covering and the arrangements for putting the cable to the bottom are more carefully attended to. It is to be hoped that those interested in that great undertaking may have profited by the experience they have gained, and that we may next summer hear of a complete success of that great undertaking, which, as far as electrical science is concerned, ought certainly to be a success.*

The CHAIRMAN: I am sure you will all join me in returning our best thanks to Mr. Siemens for the able manner in which he has brought the subject before us.

* This paper was read in the early spring of this year. Since then this *complete success* has been achieved.—ED.

Evening Meeting.

Monday, May 21st, 1866.

COLONEL P. J. YORKE, F.R.S., Vice-President, in the Chair.

NAMES of MEMBERS who joined the Institution between the 14th and 21st May, 1866.

ANNUAL.

Gould, H. C., Capt., Dorset Mil. 1*l.*
Barkworth, Thomas, Lieut., 2nd Royal Surrey Militia. 1*l.*
Curtis, James D., Commander R.N. 1*l.*

THE PRESENT STATE OF THE QUESTION OF FORTIFICATION.

By CAPTAIN H. SCHAW, R.E., Professor of Fortification and Artillery, Staff College, Sandhurst.

FORTIFICATION always has been, and doubtless always will be, as long as wars continue, a valuable aid to the weaker side in contending with the stronger; the term fortification being understood to mean any arrangement which protects the defenders from their enemy's weapons, while allowing free scope for the use of their own.

The variations in the character of the fortifications which have been used by different nations at different times, have been due chiefly to the improvements which have taken place in weapons of war, although the genius of individuals, combined with national character and local peculiarities, have also had some influence.

A very marked change necessarily occurred on the general introduction of fire-arms, and we are now witnessing a still further change, owing to modern improvements in their power and accuracy. Such changes, however, can never be made rapidly, it is only by degrees, and after the experience gained by costly experiments in peace, or the more reliable, though painful, experience of actual warfare, that certain data are obtained, and that we arrive at those combinations which most satisfactorily accomplish the objects of fortification under

the altered circumstances, and in the various cases which occur in war. A transition state, therefore, exists at each great epoch of change in the art of war, lasting for some considerable time, during which the powers of offence and defence alternately gain the ascendancy by new inventions on each side, until at length they arrive again at their normal condition of equilibrium, and fortification resumes its natural position, neither contemptible, nor yet invincible; but a useful auxiliary, in virtue of its power of delaying the success of a powerful attack, or resisting completely a force which is not considerably superior to that of the defenders.

Through such a transition period we are now passing, and when I was asked to give a paper on the "Present State of the Question of Fortification," my first impression was that it might be best defined by the one word "unsettled." On further consideration, however, it appeared to me that a certain amount of progress has been made towards the new condition of equilibrium, at which we may expect to arrive in course of time; and that an attempt to report progress, and sum up the general results of experience since the introduction of rifled arms, and to notice those points which still remain unsettled, would not be without its value. This is the aim of the present paper.

Dividing the subject, as is usual, into the two heads of field and permanent fortification, let us notice first the weapons likely to be employed in each case with their powers of offence.

Field Fortification.

An army in the field usually consists of certain proportions of cavalry, infantry, and artillery.

The action of cavalry, either in the attack or defence of fortifications, is extremely limited. A very slight obstacle will suffice to stop a body of horsemen, and prevent them from using their legitimate weapons—the sabre and lance. However important this arm may be in its proper place, we need not consider it further in connection with fortification than to bear in mind the necessity of guarding against works open at the gorge being ridden into by a rapid flank movement of cavalry. Such instances have happened; but they ought not to occur if reasonable precautions be adopted.

The weapon with which the infantry soldier of modern armies is furnished, and of which we may take the Enfield rifle as the type, possesses a power in the hands of a trained shot as superior to that of the old musket as that was to the bow and arrow. The old musket made bad practice at 180 or 200 yards, and at 300 yards it was practically harmless, while the Enfield rifle may be considered fairly effective at 500 or 600 yards against bodies of troops, even in the heat of action, and under more favourable circumstances its effective range is fully 800 yards. The penetration of the rifle bullet is also considerably greater than that of the old musket ball, and this is the more marked as the range increases.

Recorded experiments give somewhat conflicting results on this

head, but to be on the safe side, the following thicknesses appear to be needful to give security against Enfield rifles.

Earth	Clay	4 feet
„	Sandy or gravelly	3 feet
„	Sand-bags filled..	$1\frac{1}{4}$ feet
„	Gabions filled	$1\frac{1}{4}$ to 2 feet
Timber	Fir	16 to 18 inches
„	Elm	6 inches
„	Oak	6 inches
„	Birch	5 inches
„	Ash	$4\frac{1}{2}$ inches
Brushwood..	Sap roller.....	9 inches thickness of ring
„ ..	Fascines, probably	12 inches, large staff } 9 inches not 15 inches, small staff } proof.
Iron.....	Boiler plate „	$\frac{5}{16}$ inches; $\frac{1}{4}$ inch is not proof
„	Homogeneous or mild steel „	$\frac{3}{16}$ inches
Brickwork		$4\frac{1}{2}$ inches.

The power of field artillery has also increased immensely in range and in accuracy, and in a lesser degree in the penetration of the projectiles used, and in their destructive effect.

These increased powers are more particularly noticeable in the attack and defence of entrenched positions. It is probable that field batteries and horse artillery will seldom open fire at ranges exceeding 1,500 yards; because, in the field, the conditions necessary to accurate practice at extreme ranges are rarely to be ensured, viz., a knowledge of the range, level platforms, and great care in laying the guns; but when these conditions can be fulfilled, rifled field artillery is as accurate at 3,000 or 3,500 yards as smooth bored field artillery was formerly at 500 or 600 yards. The penetration of rifled projectiles is about the same at these long ranges as that of the old shot and shell at the short ranges, while the increased powder capacity of rifled shells, and the adoption of percussion fuses, give them a much greater destructive power.

As regards the effective range of case shot and shrapnel and segment shell from rifled field artillery, and the consequent lengths of lines of defence under the altered circumstances, it is only quite lately that we have come to the conclusion that the Armstrong segment shell, though very effective against troops at long ranges, is not efficient at short ranges against anything, nor against earth or masonry at any range, so that *case shot* for short ranges against troops, and *common shell* for all ranges and against all objects have been introduced. Case shot, however, is not more effective when fired from rifled than from smooth-bored artillery, nor is there as yet any altogether satisfactory projectile to fill the gap between 300 yards when case shot ceases to be very effective, and 500 yards when shrapnel and segment and common shells come into play. Moreover, as efficient flank defence by a small number of

guns implies quick firing, and as shells require time for regulating the fuzes, and are likely to be dangerous to the defenders of the line flanked by the lateral range of the splinters, &c., it appears that for flanking purposes, strictly so called, *i.e.*, for flanking a ditch or *short* space, across which an enemy might pass quickly, 300 yards is still the extreme effective range of field artillery. Although rifled guns may give an efficient cross or flanking fire over ground across which an enemy must advance to attack works at ranges up to 1,500 or 2,000 yards.

We have no experiments in penetration of rifled 12-pr. shot or shell, because the only service projectile for the 12-pr., at the time of the late experiments at Newhaven, was the segment shell, which invariably broke up after penetrating about 4 feet. We have now, however, adopted a common 12-pr. shell; and, in the absence of experiments, we may infer by comparison with the penetrations obtained by the 7-inch rifled gun, the 40-pr. and 20-pr., and using the formula, $\frac{Wv^2}{2Gd^3}$, that the penetration of the 12-pr. will be from 8 to 10 feet; that of the 20-pr. is 11 feet at 1,000 yards.

No other material than earth is likely to be used in field fortification as protection against artillery fire. Timber may be put out of the question as, if it is thick enough to resist the penetration of percussion shells, they explode in the wood and produce most destructive splinters. Hence stockades, protected by a slight covering of earth heaped against them, or blockhouses of double rows of timber with earth between, as formerly recommended to resist artillery, must now be regarded as obsolete. This lesson we have learnt at the expense of the Danes. The redoubts in the Düppel entrenchments were provided with timber blockhouses, with 5 feet of earth covering their splinter-proof roofs, and earth heaped up against the timber walls as high as the loopholes. These blockhouses formed targets for the Prussian rifled guns, which soon reduced them to ruins, unable to shelter a single man, and useless even as traverses, as each projectile which struck them caused a shower of splinters so destructive that the garrisons were obliged to abandon the redoubts, which thus fell an easy prey to the assaulting columns. It is true that the rifled guns used by the Prussians, though called 12-pr. and 24-pr., being of the calibre of the old 12-pr. and 24-pr. smooth-bores, threw elongated projectiles weighing about 20lbs. and 50lbs. respectively, and might be classed as position and siege artillery; still, the effect of lighter percussion shells upon timber would be the same in character if less in degree, and the tendency of the present day is to get the heaviest guns to the front whenever it is possible.

Masonry or brickwork could only occur in field fortification, in the case of buildings occupied for defensive purposes. By comparison with the ascertained penetration of the 40-pr. into brickwork, that of the 12-pr. would probably be about 2 feet, but as percussion shells have been ascertained to burst when they attained about $\frac{2}{3}$rds of their extreme penetration, their destructive effect upon thick walls would be very great. Probably walls 3 feet thick would give temporary protection,

but would soon succumb to the fire of rifled field artillery. At Juliers the penetration of the rifled 6-pr., throwing a conical projectile of 13lbs., with a charge of $1\frac{1}{10}$lbs., was about 18 inches into brickwork 3 feet thick, which it rapidly breached. Our 12-pr., with a charge of $1\frac{1}{2}$lb., would undoubtedly be more effective.

Thinner walls act as screens and obstacles, but give no protection against field artillery; shot merely perforate the wall; percussion shells burst after passing through. We may conclude from this (and the experience of our campaigns in India, and of the operations conducted in China by Lieutenant-Colonel Gordon, R.E., confirm the soundness of the deduction), that villages and enclosure walls may be held by infantry in spite of the fire of modern artillery; but that houses, as isolated posts, cannot be so held unless the walls be 3 or 4 feet thick, and then only for a short time; because, if the walls allow shells to pass through and to burst by the concussion, the fragments, flying on, do little injury to troops in line defending a wall, but would be very destructive in a building crowded with men.

Iron, of sufficient thickness to resist field artillery (about 3 inches), can hardly ever be introduced into field fortification; we need not, therefore, consider it.

To resist field artillery, then we may regard an earthen parapet 14 or 15 feet thick, and if possible 10 feet high, as necessary. The extra height being desirable to allow for the degradation caused by shells bursting in the parapet, and to protect the defenders in some measure from the curved fire of rifled projectiles at long ranges; for which purpose solid traverses also will become more needful than formerly. The whole question of defilade becomes, in fact, of increased importance. The extent of dangerous ground, in the vicinity of a work, is increased from a radius of 1,000 yards to 3,500, and the necessity of guarding, not only from the view, but also from the curved fire of the enemy, is more urgent then formerly, as the angle of descent of the rifled projectiles, at long ranges, exceeds the angle of descent of the smooth-bore projectiles at the shorter ranges at which they were effective.

The great difficulty in all fortification, at the present, is how to protect the guns and gunners, and yet to give the fullest scope to their fire. In field fortification, barbettes and embrasures each have their advocates, and some even recommend blinded batteries. The last-named clearly are inadmissible for the same reasons that have been urged against timber blockhouses. Barbettes have been found, in the experience of the late American campaigns, and in our own experience in the Russian war, to be useless when the enemy's riflemen can converge an effective fire upon the gunners; they are too much exposed when crowded round the gun to serve it under such circumstances. Embrasures restrict the lateral range of the gun, weaken the parapet, are open doors to let the enemy's shot into the work, and targets for him to fire at, and are soon destroyed and choked up by the combined effect of the enemy's fire and the explosion of the guns fired in them; moreover, they give but little real protection to the men serving the gun from the enemy's artillery; but when supplemented by mantlets they do protect the gunners from rifled small-arms, and are, therefore,

a necessary evil at present. The best solution of the question for field fortification which has been yet offered, is that adopted by Colonel Simmons, C.B., R.E., in the works executed under his direction for the defence of Eupatoria. Large bastion-shaped redoubts were formed at distances of about 520 yards apart, and were each armed with a battery of artillery. For serving these guns both barbettes and embrasures were formed, the former for direct fire to oppose a distant attack, the latter in the flanks to cross their fire in front of the salient, and flank the whole line, the guns being moved by hand from the barbettes to the embrasures as occasion required. To protect the camp of the garrison of each redoubt from the enemy's fire, a large traverse was constructed across it, parallel to the gorge. Such an arrangement implies large, roomy works, and the increased range of both small arms and artillery, point to the concentration of defence in a few large works rather than to dividing a defensive force in a number of smaller redoubts, as was necessary in former times, in a line of enclosed works, with intervals or curtains. The advantages of this change are considerable to the defence, all experience going to prove that 1,000 men will offer a much more effective resistance, if massed in one large work, than if divided in several smaller works, not to speak of the difficulty of obtaining a large number of officers equal to the responsibility of independent commands.

If the features of the ground permit, such enclosed works in a defensive line of field fortification may now be placed at 1,500 yards apart, or even at greater intervals, the ground between and in front of the adjoining works being so well swept by the artillery fire of each work as to make it very imprudent for an enemy to attempt to pass between them in daylight.

Two other points seem to merit notice in connection with field fortification, suggested by the successful defence of the entrenched camps of Sebastopol and Richmond, compared with the short resistance of the Düppel entrenchments. In both the former cases, bomb-proof barracks for the men guarding the principal works and batteries were constructed, and at Sebastopol approaches from the rear, to allow of their being relieved with safety, so that the men could never be driven from their works by a bombardment, but were always on the spot, ready to resist an assault. At the latter, the mistake of trying to combine the two offices of the redoubt and bomb-proof barrack in one building was one of the causes which led to the easy capture of the works. Such bomb-proof barracks seem almost a necessity in any field works constructed in the present day, with the object of resisting an attack supported by a powerful rifled artillery.

The other hint that we gather more particularly from the late American war is the great value of self-acting shell fougasses or torpedoes in the defence of entrenchments. We learn through Lieut. Featherstonhaugh, R.E., who was enterprising enough to visit Petersburg during the war, that the Confederates made great use of such accessories. A row of shells buried in the ground, with sensitive percussion fuzes and a small red flag to each, served to guard considerable lengths of line but thinly garrisoned. The moral effect of these small red flags being pretty

nearly equivalent to that of the notice "man-traps and spring-guns" to guard an orchard, and being specially valuable as a security against a surprise by night.

The exact description of self-acting fuse used by the Confederates is not known, nor is its degree of efficiency, but we are certainly not behind the rest of the world in such inventions. I am not aware whether such a fuse has been manufactured in our Arsenal; if not, it can only be needful to draw the attention of the authorities to the subject, and the talent and skill of the chemist to the War Department, and of our manufacturing department in the Woolwich Arsenal, will doubtless produce the article required.

To sum up then the present state of the question as regards field fortification, we may conclude—

1. That lines of defence may be extended for close flanking, whether of small arms or artillery, to 300 yards, and for general flanking of a line by artillery, to 1,500 yards.

2. That parapets of earth to resist field artillery should be 14 or 15 feet thick, and, if possible, 10 feet high above the terreplain (which may in some cases be sunken); and that breastworks to resist small arms must be slightly thicker than hitherto.

3. That villages and enclosure walls may be advantageously defended against an artillery attack, but that isolated buildings, even if very strongly constructed, must soon succumb to the fire of percussion shells from rifled guns.

4. That timber can only be used to give cover against artillery when itself completely protected by earth. That blockhouses and stockades are therefore inadmissible against artillery, but that bomb-proof barracks under traverses or parapets are almost a necessity to protect the garrison of important works (particularly those which are enclosed) against a powerful artillery attack.

5. That field works generally, even the simplest breastworks or rifle pits, are more valuable than hitherto in enabling a weaker force to defend a position against a stronger. The almost universal experience of the late American war leads to this conclusion. The increased value of cover being, in an open country, directly in proportion to the increased range and accuracy of the modern infantry arm, or nearly as 3 : 1; because the assailants are, in such a case, now exposed to an accurate fire for 500 yards, instead of for 180 yards as formerly, while the defenders are sheltered, so that by the time the storming party closes, their numbers and confidence must be woefully diminished.

6. That enclosed field works, although as valuable as ever to the defence, are by far more difficult to construct and guard than hitherto, inasmuch as they must be exposed to a concentrated fire of artillery and small arms from great distances, the projectiles from which strike the work at a steep descending angle, rendering the difficulties of defilade very much greater than formerly. Hence arises the necessity for high and thick parapets, heavy traverses, and bomb-proof barracks in such works, all entailing a great increase of labour.

7. That it follows from 5 and 6 that the field works thrown up on the eve of battle must be, in almost all cases, in the form of lines,

either continuous or with intervals; but that when time and means are available, large enclosed works armed with artillery (at intervals as great as 1,500 yards, if the features of the ground permit it), either independent or connected by trenches, or obstacles, or by a parapet and ditch, according to circumstances, would be the best general form of field entrenchment.

8. That neither embrasures nor barbettes are satisfactory modes of ensuring the action of artillery behind parapets, and that the best solution of the difficulty, in the case of field works yet offered, is to provide both barbettes and embrasures for the guns, the former for distant action, the latter for close flanking fire.

9. That self-acting fougasses may be largely used as accessories in the defence of entrenched camps or positions.

Permanent Fortification.

Permanent fortification may be considered under two heads, viz., inland fortresses and coast defences; because the latter have to deal with the exceptionally heavy guns and defensive armour of iron-plated ships, the great weight of such guns precluding them from being employed in ordinary sieges.

The new artillery which will now be employed in the attack and defence of fortresses has been compared with the old in a lecture given in this theatre by Major Owen, R.A., on 15th May last. I need not therefore recapitulate the very full and interesting information given in that lecture, but only supplement it by a few facts and observations.

1st. As regards ranges in the attack and defence of permanent fortification. In one point we have lost ground by the adoption of rifled guns, viz., in the power of firing grape, which from smooth-bore iron ordnance was effective at 600 yards, as experienced by us at the siege of Sebastopol. No projectile, as yet adopted for our rifled garrison guns, quite takes the place of this formidable missile. The case shot invented by Lieutenant Reeves, R.A., and lately adopted for our rifled guns, has not been tried at greater ranges than 300 yards, as far as I am aware, and the balls are probably too light to be effective at greater ranges.* The shrapnel or segment shells are, however, terribly efficient at ranges from 500 yards to 1,500 or 2,000 yards. What we appear to want is a fuse that will, without any adjustment, ignite the bursting charge of these shells with certainty at about 200 yards from the muzzle, and be capable of adjustment for longer ranges. For guns to be used exclusively in flanks, we have the option of using smooth-bore ordnance throwing grape. Hence we have as the limit of close flanking fire for ditches, 600 yards, providing that if the line of defence be so long, the number of guns in the flank must be considerable, as a portion of the guns would be required to fire grape or shrapnel for the most distant part of the line, and part to fire cannister

* For the larger nature of ordnance case-shot containing heavier balls have lately been introduced.—H.S.

for the near defence. The flanks of the kaponiers defending the main ditch of the great enciente of Antwerp have each 14 guns in casemates, and 5 in an open battery on the roof, the lines of defence being from 500 to 600 yards, and the guns rifled 24-pounders, throwing a 50 lb. shell. For the intervals between detached works mutually supporting each other, 2,000 yards may be considered the limit. The most effective ranges for direct and enfilade fire against works in the attack and defence of fortresses, are considered to be 2,000 yards for the former, and from 900 to 1,450 for the latter, which also includes the curved fire necessary for destroying hidden revetments, but considerably greater ranges may be used effectively if necessary. Bombardments are now possible at ranges as great as four or five miles, if the object to be hit covers a large space, and can be seen from such distances, although they would seldom be attempted from a greater distance than 5,000 yards.

The penetration of rifled siege and garrison artillery into earth, and the effect of the large bursting charges in their elongated shells, is so great that parapets are now made at least 25 feet thick, and 10 feet high, to resist these guns, and the exterior slopes are made much more gentle than formerly. The effect upon brickwork and masonry is so much greater than that of smooth-bore ordnance, and at such increased ranges, that the effectual defilading of all masonry from distant artillery fire by covering masses of earth is essential. When such defilading is impossible, iron is proposed to protect the masonry, but it has not yet been employed for the purpose as far as I am aware. Experiments which are to be made at Shoeburyness shortly, will throw more light on the subject of protecting masonry against breaching by ordinary rifled siege artillery than we possess at present.

It must, however, be remarked that in the present day we cannot calculate upon only ordinary siege guns being employed in the attack of important fortresses. Railways have so far facilitated transport that even inland fortresses cannot be considered secure from the attack of exceptionally heavy rifled guns, nor, on the other hand, can the besiegers calculate on finding only the ordinary garrison artillery in the fortress attacked, and a few well-protected large guns on either side would give a very great advantage to the side possessing such exceptionally powerful weapons.

Another auxiliary which probably will be largely used in the attack and defence of fortresses is the rifled wall piece. Such a piece, with telescopic sights, and throwing a steel-pointed, elongated projectile, would combine long range, accuracy, and penetration, with mobility, and would be so difficult to silence, being served by one man, firing through an ordinary loophole over a parapet, that it would tend much to keep down the fire of heavy guns, and to retard the progress of saps. We learn that the Federal Americans used such wall pieces in the siege of Petersburgh, and that they were very effective in keeping down the fire of the Confederate guns. The accurate range of rifled wall pieces would be at least 1,000 yards, and the penetration of the projectiles would be sufficient to pass through ordinary mantelets,

gabions, and musket-proof parapets; but there are no experiments to give exact data on the subject.

Vertical fire is in about the same position as formerly. Experiments with a rifled howitzer, throwing shells at high angles of elevation, have been tried at the suggestion of the Inspector-General of Engineers, and the results have been very satisfactory as regards accuracy, although a difficulty has been experienced in the manufacture of percussion fuzes, sensitive enough for use with projectiles striking with comparatively low velocity, and yet not so sensitive as to be dangerous.

Such being the altered position of the artillery question as regards permanent fortification, let us notice the effects it has had, or is likely to have, upon the defence and attack.

1st. The defence.—The alterations in the design of permanent fortification which have been introduced since the last great European war, have originated from the obvious necessity of protecting the garrison from vertical fire by providing a sufficiency of bomb-proof barrack accommodation, which may generally also be made defensible, and act as a redoubt or interior retrenchment, and of securing the guns required for flanking the ditches from the distant fire of a besieger, thus introducing the principle of "reserved defence," as it is termed, *i.e.*, that the defenders should, by skilfully disposed works, reserve some batteries of artillery in positions secure from the distant fire of a besieger, and placed so as to sweep the ditches and ground immediately outside the fortress; it being an established fact that to cross a formidable obstacle such as the dry ditch of a permanent fortification, under the sustained flanking fire of artillery, and in the face of a reasonably determined direct defence, is almost an impossibility, even should breaches have been formed in the escarp or counterscarp; and to bridge a wet ditch under such circumstances would evidently be out of the question.

In order to reserve the flanking guns until the last period of the siege therefore, the open flank of the bastion system, which is peculiarly liable to be silenced by the distant fire of artillery, has given way to the casemated kaponier of the German or polygonal system. The French, for so long advocates of the bastioned system, "*pur et simple*," have practically adopted the kaponier in their latest works, and are now teaching the polygonal system in their military schools, although the traditional advantages of the bastion are still insisted upon.

The kaponier being thrust forward so much more than the flanks of a bastion, is evidently more easily assailable by mines, and therefore requires a system of countermines to oppose such an attack. These countermines exist in almost all the new German fortresses. The advantages for the defence derived from the use of the kaponier instead of the bastion flank, are given in most modern works on fortification; but one of the most valuable is the independence of the enceinte from the flanks, both as regards trace and relief. In extended lines of fortification, such as the great enceinte of Antwerp, the lines of defence may be at a maximum, and thus the number of vital flanking points

is reduced to a minimum, with corresponding advantage to the defence, while in detached forts the lines of defence may be as short as is necessary or convenient, retaining at the same time a formidable relief.

In many of the German fortresses constructed prior to the introduction of rifled artillery, Montalembert's views have been so far adopted, that several tiers of guns in casemated buildings are exposed to the distant fire of rifled guns. Whatever might have been the value of such works in former days, it is clear that they can now add but little to the strength of a fortress subjected to a regular attack.

To protect the masonry of casemated batteries from the enemy's projectiles, earthen merlons are frequently formed in front of them, after the method of General Haxo. In order to give these merlons sufficient strength, it is necessary to blind every alternate embrasure, hence only half of the guns can be used at one time; should any of these, however, be silenced by the enemy's fire, the blinded embrasures can be opened and the injured ones closed with the earth at night, in a very short time. Haxo casemates, forming also traverses, are largely used on ramparts exposed to enfilade fire, and if covered with a sufficient mass of earth, they give great security to guns, when not exposed to direct fire. When these are not used it becomes necessary in such cases to nest each gun between two solid traverses. All these arrangements diminish the number of guns which can be placed in a fortress; but there can be no doubt that a few well protected guns are better than a larger number exposed to destruction by the enemy's fire. In one instance (at Diest, in Belgium), an expedient is adopted which is novel and ingenious, its value is variously estimated, and must be decided by experience. An arcade is built at some little distance in front of the casemate battery, through the arches of which the guns fire; deep graves are dug between the piers of the arches, to receive the débris of the arcade, should it be destroyed by the enemy's fire. The danger of the rubbish of the arcade masking the guns is thus, it is hoped, avoided.

Embrasures in permanent, as in field fortification, are the great difficulty. Barbettes are provided on the ramparts of some continental fortresses with bonnets at intervals, and large vaulted traverses for the security of the guns when not being served; a certain proportion of embrasures being also formed for flanking important points. It is questionable whether shrapnel shells would not make it impossible to serve guns on such barbettes. It is much to be desired that some method should be devised of raising and lowering the guns, so as to avoid embrasures altogether, and we may hope that ere long such a method of serving guns on ramparts may be introduced.

Iron cupolas are proposed by some engineers to be placed at intervals on a rampart, so as to give very great security to a limited number of guns; foundations for such cupolas are prepared on the keeps of the detached forts at Antwerp. The expense of the cupolas, and the probability that either they would be injured and put out of working order by a concentrated fire of artillery, or that the gunners would find the place too hot for them if exposed to a concentrated fire of wall

pieces on the embrasure, are the objections raised. Experience must decide.

The general tendency of permanent fortification of late years has been to suppress the numerous small fortresses which formerly studded the frontiers of States, and to concentrate the defences in a few large fortresses, surrounded by detached works, and forming great intrenched camps, which are secure depôts for stores and provisions, bases of operations for offensive campaigns, and asylums for an army in case of reverse. Such fortresses are too important to be blockaded and passed by, and their sieges present extraordinary difficulties.

1st. Because the investment of so extensive a line is almost impossible.

2nd. Because the advantage ordinarily enjoyed by the besiegers of surrounding the work attacked by batteries bringing a converging fire upon it is here impossible, owing to the near approximation to a straight ine of the general trace.

3rd. Because the detached forts which must first be taken by regular siege can be supported, and their garrisons relieved from the rear.

4th. Because such remarkable facilities exist for sorties on a large scale between the detached forts.

5th. Because supposing two of the forts taken (the least number that would suffice), the main enceinte, defended by an army, remains to be overcome.

In these large modern fortresses the system of communications is very much simplified, with the object of allowing large bodies of troops to move out rapidly for sorties. It is no longer a question of a small body of men shutting themselves up within a line of impenetrable obstacles, with one or two narrow entrances guarded with every care, and passing through a series of outworks. These large modern fortresses are rather prepared battle fields, where an army inferior in numbers, or morale, can fight with the greatest advantage under the support of a powerful artillery. The outworks and covered ways, and in some cases even the ditches, are all prepared for this active defence, broad roads with easy ramps being formed to allow a whole army with cavalry and field artillery to issue forth suddenly from under cover, and to retire with equal facility.

The danger of an enemy repulsing a sortie and pursuing the beaten troops so closely as to enter the place pell-mell with them, is guarded against by tracing the roads leading into the place, close under the fire of enclosed redoubts in the place of arms, but not passing through them, as formerly was the case, and directing the roads, so that as the main entrances through the ramparts are approached, one concealed battery after another is discovered sweeping the road. The rear of an enemy's columns would thus be annihilated by the fire of the place before the head had reached the entrance gate.

The successful defence of Silistria, and the long protracted siege of Sebastopol and Richmond, sufficiently illustrate the difficulties of besieging such large fortresses, when it is remembered that the works attacked in all cases were field-works without revetted ditches, or any of the regularly constructed works of permanent fortifications to facili-

tate powerful sorties or retard the besiegers. As long as provisions can be supplied to the troops defending these great entrenched camps, they may be regarded as practically impregnable, if vigorously defended.

Apart, however, from the consideration of the precise system of fortification, or of the extent of the fortified position, the question has been much discussed whether the gain to the attack or to the defence has been the greater by the introduction of rifled artillery.

It is difficult to give a satisfactory reply to the general question, because so much depends upon the size of the place attacked and the nature of its defences. If we take a small fortress of the old type, and arm it with rifled guns, and attack it with similar weapons, the advantages are clearly on the side of the attack. It is true that the parks and depôts must be placed at a much greater distance than formerly, and that the earthworks must be more substantial, and therefore require more labour; but, on the other hand, the 1st batteries may be placed at a great distance from the place, and converging an accurate and powerful fire of large shells upon the fronts attacked, their fire must inevitably be silenced in a very short time.

The first batteries being so far from the place, no first parallel will be required for the guard to secure them from sorties, as in almost every case sufficient cover may be obtained with very little labour to screen troops from the view of an enemy, at a distance of 1,500 or 2,000 yards—sorties at this distance from their works would be a losing game for the defenders of such a fortress.

The parallels and approaches can then be carried on rapidly, undeterred by the artillery fire from the place, and it is probable that in most cases the scarps may be breached and the flanking fire subdued without advancing the batteries at all, because it was not formerly necessary to defilade masonry from heights at a greater distance than 600 or 800 yards, and it will frequently happen that favourable positions for breaching batteries may be found at distances between 800 and 2,000 yards. Should this, however, not be the case, the latter part of the siege will probably be more advantageous to the defence than to the attack as compared with former times, because the fire of small arms, including wall pieces, is more accurate and penetrating, and this must evidently tell more to the advantage of those who possess cover and only maintain their ground, than to those who have to make cover and advance. The balance is still further on the side of the defence as regards the difficulty of making covered approaches, if we concede to them the modern inventions for throwing a strong light by night on the ground over which the besiegers must approach. In such cases then, a General would probably feel himself justified in pursuing the course adopted by the Duke of Wellington in the sieges in Spain: he would have the great advantage of being able to breach walls, with an incomparably smaller expenditure of ammunition, from distances quite out of the effective range of small arms, and of assisting the assault by a concentrated fire upon the fronts attacked, continued until the assaulting columns were about to descend the counterscarp, the plan adopted with such complete effect in the late capture

of the Düppel entrenchments; or even to fire over their heads, as at St. Sebastian.

Against second class fortresses, then, of the bastion type, or in which the scarps are exposed within breaching distance (2,000 yards), we may conclude that the improvements in artillery give the advantage to the besiegers, and lead to the adoption of the artillery attack, omitting all the most difficult and tedious part of a siege, and sacrificing a certain number of men in an open assault, rather than in the fatigue and constant small casualties of a protracted siege. Time, so important in war, is thus gained, and probably no more lives are lost.

Supposing, however, the attack to be against a large fortress, armed with a powerful artillery, probably heavier and certainly better protected than that of the besiegers, with wet ditches, or well covered scarps, casemated flanking batteries, and the various resources of reserved defence, and supplemented by an efficient system of countermines. The case is apparently much altered, and the advantage is considerably on the side of the defence.

In well constructed polygonal fortresses the only faces subject to enfilade are those of the couvrefaces or ravelins, and these, if protected by bonnets and traverses, and by Choumara's method of making the parapet, independent of the escarp or ditch, are far less liable to enfilade than the old pattern ravelin. Counter-batteries would therefore have to be resorted to in most cases, and an immense siege train becomes necessary. Captain Hutchinson, R.E., in a theoretical attack of the fortress of Posen, which cannot be considered in any way a model fortress, estimates the minimum siege train to undertake the attack at 140 pieces.

The establishment of the batteries under the fire of a powerful artillery would be very difficult, and the labour would be very much greater than formerly, owing to the great thickness of parapet necessary, and the consequent greater distance between the guns, if embrasures be used. The magazines must also be constructed with a much greater thickness of earth over them than formerly.

Colonel Brialmont, of the Belgian service, proposes using barbettes for the first siege batteries, enclosing the guns in redoubts. It is very doubtful, however, whether guns could be so served for any length of time. The fire of shrapnel shells would probably make it impossible. If embrasures are a difficulty in permanent works, far more so are they in siege batteries, and any mechanical aids for raising and lowering guns so as to dispense with them, would be evidently less applicable to the siege of a fortress than to its defence.

However, supposing the batteries constructed and armed, and at distances of from 1,000 to 2,000 yards from the place, and that in due time the direct fire from the ramparts had been overpowered, it must be remembered that it would not probably be nearly extinct. The defenders, if well instructed, would withdraw their guns behind the merlons and traverses during the day, and replace them at night, so as to be able to concentrate their fire on any new work of the besiegers in the morning, or to repel an assault. Between this intermittent fire of artillery and the constant fire of wall pieces and small

arms, the approaches would be sorely retarded. Add to this increased labour and difficulty, the fatigue consequent on the long marches which the working parties and guards must make from their camping ground to the front, owing to the necessity of encamping them out of range of rifled guns, the extra labour of bringing up materials and ammunition from the distant parks and depôts, and the probable failure of the ordinary aid which darkness lends to the besiegers, from the employment of modern artificial modes of throwing light upon the field of attack, and the danger of powerful sorties, destroying in a few minutes the work of a night, and it must be admitted that the second period of the siege is certainly more arduous to the besiegers in such a case than heretofore.

Let us imagine that the approaches have been carried up to the third parallel, then begins the war of mines, which may last probably for more than a month, and at its conclusion the most difficult and dangerous operations of a siege have to be commenced, under circumstances far more disadvantageous than formerly; for if the principles of reserved defence have been skilfully carried out in the fortress, the besieger, in attempting to construct and arm his breaching batteries on the crest of the glacis, will find himself opposed to a powerful artillery in secure positions, which he had not been able to oppose by his distant fire, or only in such a blindfolded manner as probably not to have injured it materially.

At this point, then, we may leave the attack and defence of inland fortresses, in which category we may include the chains of forts surrounding the land fronts of our great naval arsenals, partaking, as they do, of the nature of entrenched camps. Their primary object is to prevent an enemy from establishing batteries within bombarding distance of our dockyards, by occupying or commanding the ground suitable to such an enterprise by forts so strong and powerfully armed, that, although requiring a small number of men for their garrison, they must be regularly besieged. An enciente of sufficient strength to resist a *coup de main* girdles the vital points to be protected.

The space between these two lines forms an admirable position for an entrenched camp in which to assemble troops in case of an invasion. As we are more interested in the defence of our own country than in the attack of our neighbours, it is well for us that the major part of our system of national defence is being executed in modern days, and is adapted, as far as we can judge, to the conditions of modern weapons. If the tempest now lowering on the continent bursts, we may shortly have some more certain data on the subject than we at present possess.

The sea defences of our island are of great importance to us, and we must, in conclusion, summarise briefly the present state of the question as regards this class of fortifications.

The nature of ordnance which may now be brought to bear upon coast and harbour defences is of such prodigious power that to obtain any structures sufficiently strong and enduring to resist their attack, is a problem of extreme difficulty. The monster guns which we possess and with which all foreign nations are supplying themselves, in smaller

or greater numbers, have been fully described by Major Owen, in his lecture before referred to. Their range is even greater than that of the ordinary siege artillery, their penetration and the bursting charges of their shells so great, that by common consent the strongest material with which we are acquainted must be employed to resist them. The problem may be said now to be rather how best to apply iron than whether to use it or not. Is it to be used alone, or in combination with stone, or wood, or earth?

The result of the latest experiments at Shoeburyness appears to lead to the conclusion that the combination of granite and iron is not satisfactory when likely to be exposed to a number of blows from these very heavy guns. The full value of the protection afforded by iron shields is not obtained in such cases, as the granite is so much more easily destroyed than the iron, that the casemates would be rendered untenable long before the iron shields ceased to afford protection.

If iron alone be used, a greater number of guns can be placed on a given front than if granite be used in combination with iron, and the protection afforded will be more complete, but the expense will be greater. Whether it is possible to protect the same number of guns with iron alone as with granite and iron in combination, for the same money, is still an open question. Were this point settled, the advocates of granite and iron would still claim better barrack accommodation and greater durability in peace. The iron sides oppose to these advantages better protection and greater facility of repair after an attack, and a smaller mark to be fired at. The best method of applying iron, either alone or in combination with masonry, can hardly be said to be decided, although Captain Inglis's shields appear to be quite satisfactory for the latter case. The mode of construction to be adopted in each instance must depend upon the probability of a continued and concentrated fire being brought upon the work, which, in the case of sea defences, it must be remembered is a very rare occurrence.

The combination of iron with earth has not yet been experimented upon, but it appears probable that it would be advantageous, in some situations, to avoid the great difficulty of embrasures in very thick parapets.

Coast defences may either be intended to prevent a landing in some favourable position for an enemy's base of operations, or to prevent an enemy from using a channel leading to an important harbour, or to destroy any vessels that may have run in and attempt to bombard an arsenal or dockyard. They consist of batteries of guns, and submarine mines as active defences, and booms as obstructions and obstacles. The batteries intended to prevent a landing are placed so as to bring a cross fire of round shot, shells, and grape on ships lying in the offing, and on boats passing from them to the shore. These batteries are usually of earth, with a loopholed wall, arranged for flank defence to close the gorge and prevent their being taken by surprise or a sudden rush. This construction appears well suited for the case when convenient sites present themselves sufficiently elevated

to give them a command over ships and lessen the danger from broadsides of grape and shells; when necessarily placed in low positions, and liable to such attacks, they are casemated and the entrance of each vault protected by an iron shield. Such a construction, though liable to destruction by a concentrated or long-continued fire of very heavy guns, as proved by the experiments before alluded to, seems, nevertheless, admissible in cases when supported by earthen batteries on high ground on the flanks, which would make it extremely hazardous for even iron-clad ships to attempt an attack of any duration on the more vulnerable casemated battery in the centre. Such a case exists at Sandown Bay, in the Isle of Wight.

To close a channel not exceeding 1,500 yards in width, and of considerable length, it may be sufficient to place a succession of batteries on convenient sites along the shores, raking the channel and crossing their fire over it. When sites for batteries, of sufficient extent, do not exist, casemated structures, having guns on two or three floors, become necessary.

By multiplying the guns and extending their action over a considerable length of channel, the chances of hitting a moving object are greatly increased; but the very great difficulty of hitting a steamer moving rapidly up to, and past a battery, at some distance from it, can hardly be appreciated by any one who has not seen artillery practice under conditions somewhat similar. The constantly varying range, the difficulty of training the gun with sufficient rapidity, and of allowing for the time of flight of the shot, and the distance passed through by the vessel during this time, all combine to make this kind of shooting extremely uncertain in its results. The necessity for using very heavy guns, unwieldy to move and slow to load, in order to have any effect on iron-clad ships, increases still further the chances in favour of a ship attempting to run the gauntlet, and makes more evident the necessity for every possible mechanical aid for working such large guns.

If the channel be wide, intermediate batteries become necessary, as at Spithead, where the problem of forming good foundations, and of placing on them the greatest number of the most powerful guns; of protecting them against the most formidable naval attacks; and of giving at the same time the greatest extent of range, and the greatest possible freedom of action and rapidity of fire to the guns so protected, without an extravagant expenditure of money, is a question most difficult of solution, and which is still unsettled. But whatever the construction finally adopted, it is evident that no guns can be used *en barbette*, and that those portions of the walls at least, through which the guns fire, must be of iron, the embrasures being reduced to a minimum, with the double object of giving better cover to the interior, and greater strength to the walls. This may be attained probably by the use of muzzle-pivoting carriages for elevation and depression, such as described in this Lecture Theatre by Lieut.-Colonel Shaw, R.A., and of either cupolas or some mechanical arrangement of a similar character for traversing.

From what has been already stated with regard to the difficulty of

hitting moving objects, it will be evident that every auxiliary which can be brought to bear upon the defence of coasts and harbours will be valuable. Booms are a very old expedient for obstructing a passage. To resist the charge of modern iron-clad rams they must now be of immense strength. Another more modern appliance which the Russians were the first, I believe, to bring into notice, is the submarine mine or torpedo. We learn that in the late American war these formidable defences were much used, and were very effective in the defence of rivers and harbours. The subject is a large one, opening up quite a new field of inquiry and invention. A committee is now engaged in experimenting upon, and investigating the laws of, submarine mines, and we may hope that the result of their labours will put us in possession of a most effectual and formidable defence for our harbours and dockyards. The moral effect of these unseen and terrible foes, by which the largest and most powerful ship may be destroyed in an instant without the possibility of escape, would be so great that the mere knowledge that a really effective system of torpedoes existed would probably be sufficient to deter the most desperate naval commander from attacking a harbour so defended. The guns would then serve to protect the mines from being disturbed, and the mines would be the real defence. Such a mode of harbour defence is undoubtedly quite practicable in most cases, and it would be the most economical, by reducing the number of guns, batteries, and gunners that would be otherwise necessary.

A moveable mine, consisting of a small iron-clad steamer with a long beak, projecting under water, and supporting a case of gunpowder or other explosive composition, which charges a large ship and blows a hole in her bottom, is another form of torpedo which has been effectively used in America, and we read that some successful experiments in this direction have lately been made in France. The details of this sort of torpedo belong rather to our Naval brethren's department, but it is likely to prove a valuable aid to our harbour defences, and one quite suited to the genius of our Navy.

The CHAIRMAN: I will ask you to return your best thanks to Captain Schaw for the valuable communication he has just made to us of the present state of the question of fortification. There seem to be a good many difficulties connected with the subject. There are officers present who have taken great interest in the subject, and there is certainly one (Colonel Jervois) who has had a very intimate connection with the construction of works. I hope he and other gentlemen will favour us with some remarks upon the paper.

Lieutenant-Colonel JERVOIS, C.B., R.E., Deputy Director of Fortifications: I am sure we are much indebted to Captain Schaw for the very able lecture that he has given us upon the present state of fortification. He has gone through various questions connected with field and permanent land fortifications, and with many points, so far as known to the public and to himself, with reference to our coast fortifications. Of course it would be impossible to follow him through all these. I mainly agree with him in what he has said with regard to field fortification. Having, however, visited the works of Richmond and Petersburgh after the attack, I may remark, in passing, that I do not think their defence depended so much, as he has been informed, upon bomb-proof barracks, and communications to the works. Bomb-proof batteries were very rare in the Confederate works, and the communications to them, that Captain Schaw referred to, I think, scarcely existed. I believe

the defence of Richmond depended more upon field operations than on the works. At first there were attacks made on certain points by trenches, batteries, and mining, as usual in siege operations, and at Petersburgh, where the Federals blew up an enormous charge of powder, they would probably have succeeded in storming the breach thereby effected, if the assaulting party had been sufficiently game to go in after the crater was formed. But failing to do so, they got rather sick of regular attack, and they took to working round the flank of the Confederates; Richmond was captured by the defeat of the Confederate army on the right flank of the Petersburgh entrenchments, and not by the taking of the works. With regard to details of permanent land fortifications, I think the application of iron must come into play: but it appears to me it would be a mistake and an unnecessary expense to apply it in time of peace in inland works. We should have an arrangement by which we may apply iron at whatever part of the work or works the attack develops itself. In that way we may put up an iron shield or shields; these may be in store; and we may, at the commencement of a war, put cupolas on our works of this sort if considered desirable, and make other arrangements for putting them into a state of defence. As regards our sea fortifications, I think a good deal of misapprehension exists as to the merits of the case with regard to forts consisting of a combination of granite and iron. In order to test these, two casemates were lately erected at Shoeburyness. After firing 87 shot at them—65 shot at the iron portion, 22 at the granite portion—the granite part was destroyed. I have gone into the question as to what would be the actual number of shot that would take effect during a naval action upon an area of the same extent as that fired against at Shoeburyness; and I find that in the attack on Fort Sumter—the only one of which we have reliable data (I have the confidential report which was made by the Confederate officer of engineers on the subject)—that out of 80 shot fired at Fort Sumter, only 58 struck, say three-fourths; only a portion of those struck effectively. But, we will suppose that three-fourths struck the parts of Fort Sumter which were exposed to fire. That would, in the case of the experiments at Shoeburyness, give three-fourths of 87 shot hitting the work, that is, 65 shot upon, about 700 superficial feet. Now the number of superficial feet exposed at Fort Sumter was 8,000; the number of shot, therefore, that would have hit the two casemates at Shoeburyness, supposing a similar attack on the work of which they formed part, to that which took place at Fort Sumter, would have been about six instead of 87. Every one who saw the experiments would at once admit that six shot would have produced no effect whatever as regards silencing the guns, or effective damage to the interior of the casemates. It was not, as my friend below me, Captain Heath, will recollect, until the thirty-third shot upon the granite, that the casemate commenced to be untenable. I think, therefore, for all ordinary cases, if not for all cases, it would be found that the granite and iron structure would give the necessary degree of invulnerability. I do not mean to say that by spending more money you cannot obtain a better structure. Undoubtedly you can. We knew that before we made the experiment. But you cannot obtain a structure that will give you the same degree of invulnerability at the same or at a less cost. Whether it is desirable to expend that larger sum of money is a question more for the Chancellor of the Exchequer than for engineers. If he desires to have more invulnerability, it can be given. There is one great advantage that can be obtained in the iron structure, viz., that we can add strength to it, which cannot be done in the case of granite. Also, there is no dust from the iron, and there is a great deal of dust from granite. On the other hand, as Captain Schaw remarked, granite costs nothing in maintenance, whereas the iron would be comparatively expensive in maintenance. Again, a more habitable casemate for troops can be made of granite than of iron. I think it will be found that granite, with iron shields at the embrasures, will give all that is required in the majority of instances. There may be certain cases, however, where an isolated work is exposed to great concentration of fire, where it may be desirable to give the additional strength that would be afforded by an iron fort; but it would not be advisable to do so except in particular cases. There is one other instance I may refer to, in which it may be desirable to have an iron fort, namely, where your foundations are difficult.

The CHAIRMAN: There is a considerable difference of toughness in different kinds of granite.

Colonel JERVOIS: We fired at different kinds of granite, and we did not find there was much difference in them. Whilst upon the subject of granite works, I may state that the Americans are constructing granite works at an immense expense. They are constructing them of four tiers in height, with guns on the roof *en barbette*. The strength they are giving to their works is much less than that which we have thought it necessary to give; they rely apparently more upon the number of guns than upon the strength of the works. I believe the direction of our expenditure should be rather more with the view of getting a gun that will smash the ship than of obtaining an invulnerable fort.

Captain HEATH, R.N., C.B., Vice-President Ordnance Select Committee: I am sorry to differ from Colonel Jervois in his estimate of the value of granite forts. I saw the experiments at Shoeburyness to which he refers. He has given the numbers quite accurately. Twenty-three shot, mostly steel, struck the iron shields, and 65, mostly cast-iron, struck the granite part of the work, but the superficial area of the shields was 109 feet, and that of the granite was 514 feet, so that whilst on an average 1 shot was planted on every 5 feet of the shield, the proportion which struck the granite was 1 to every 8 feet, nevertheless, whilst the iron resisted very well, the granite was almost demolished. The comparison between Fort Sumter and such forts as the Spithead forts, is hardly one to the point; because I believe the diameter of the Spithead forts is to be 200 feet, so that, as round forts, the portion exposed to a hostile fleet could never reach the 8,000 yards superficial of Fort Sumter. Shortly after this experiment had been made, I calculated that iron-clads at 600 yards would reduce, in two hours, any fort built as those casemated forts at Shoeburyness were built. I forget the exact figures, but I think I made out that four iron-clads, anchored pretty closely, would oppose a space such as that casemate represented, and would certainly send 87 shots in two hours and a half at those forts. The answer to that was, "The forts will not be idle, and your iron-clads will be sunk." To that I answered that no Government would dream of attacking forts of that nature without having first carefully prepared their expedition, and would not be contented with four iron-clads, but they would probably have twenty. There would be four attacking and sixteen in reserve, and, somehow or other, I think in two hours and a half the fort would be reduced.

Colonel JERVOIS: I said 8,000 feet was the area of the exposed part of Fort Sumter. But the Spithead fort will be 200 feet in diameter, and allowing 40 feet for the height—the height is more than that—that makes 8,000 feet.

Captain HEATH: But I do not think a fort built solely of iron need be 40 feet high. I think an iron fort should be built more like an iron ship, where seven feet between the decks are found to be quite enough. You would then have two tiers in twenty feet, and on the top you would have your turrets. I think those great forts for the protection of Spithead, and others of that nature, if they are built at all, should be built in the firmest and safest way. We should not look to the guns we have now, nor to the projectiles of the present day, but should make our forts fit to resist the guns of the next generation, which will assuredly be of still heavier calibres.

Vice-Admiral CODRINGTON, C.B.: There is one point upon which I think we want a little more information, namely, the expense of this iron work on forts. We know the cost tolerably well with regard to ships, but not with regard to forts. There is one specimen—perhaps, Gentlemen, may not know it, but I happen to have seen it the other day, therefore it is worth something as a basis of calculation. At the Millwall Company's works I saw a specimen of iron, beautifully joined, which had been made by that company for a fort recently built, and to be cased for the Emperor of Russia at Cronstadt. I think the fort to be cased was a three-gun fort. The iron was nine inches thick, and the work was most beautifully done. The system of jointing was very good. There were nine inches of metal to be penetrated. But when we came to consider what was the expense of this, they told me that it was no less than £1,700 for one lineal yard. Now any gentleman can consider what that would be for a three-gun fort, of the average height, that would give cover to those

who work the guns, and with room between for the working of those guns; and if there are to be any traverses, there will be so many more lineal yards of frontage. But when we come to reckon that up, at £1,700 for each lineal yard, it seems to amount to a very large sum indeed; it would be dearer, I think, than anything we have contemplated yet.

The CHAIRMAN: The lineal yard included the entire height?

Admiral CODRINGTON: The entire height.

The CHAIRMAN: You do not remember the height?

Admiral CODRINGTON: I do not recollect exactly the height. It was of a height necessary to cover the battery. The specimen is to be seen at the works.

The CHAIRMAN: Should no other gentleman wish to make remarks, Captain Schaw will perhaps now reply to the observations that have been made.

Captain SCHAW: There was a question asked about the cost of iron forts. I do not feel able to go into it. It is still an unsettled question. I will mention that, as regards the bomb-proof cover at Petersburgh, to which Colonel Jervois referred, my authority was Lieut. Featherstonhaugh. He states that there was a great deal of cover of that description at Petersburgh; but he did not visit Richmond, and he does not mention communications from the rear. At Sebastopol, however, both the bomb-proofs and the communications undoubtedly existed.

A VISITOR: I would ask, with regard to the battery which is to be seen at Millwall, whether the guns are on the same level or in tier?

Admiral CODRINGTON: There is no battery at Millwall. The battery is in existence now, guns and all, at Cronstadt. I only saw at Millwall a specimen of the iron casing, which stands about five feet high, and is to be seen as a specimen of the iron.

Colonel JERVOIS: I believe I know the cost of it and the dimensions of it. It is about forty-four feet long, and about eight feet high. It cost in round numbers about £6,900.

LECTURE.

Friday, June, 1st, 1866.

COLONEL P. J. YORKE, F.R.S., Vice-President, in the Chair.

COMMISSARIAT OPERATIONS IN THE FIELD.

By E. B. DE FONBLANQUE, Esq., Deputy-Commissary General

IT is in no conventional form that I have to ask your indulgence for the observations I am about to make, for I labour under the double disadvantage of addressing you for the first time, and of introducing a subject which is open to the suspicion of being dry and unpopular. But that track must indeed be barren and sterile which should offer no points of interest to one who has passed the best part of his life in traversing and labouring on it; and I am not without hope that a better acquaintance with the Commissariat, and the duties which devolve on it, will lead my audience to extend to the subject of my lecture, a greater degree of forbearance than my mode of treating these questions would entitle me to claim.

About ten years ago, having devoted some time to the study of the French system of army administration, I endeavoured to make the subject interesting to those connected with our own service, but, with a few notable exceptions, I met with complete indifference; the very meaning of army administration was unknown to a large number of military men; and though they could not but be aware that certain so-called civil departments existed for the purpose of supplying the material wants of the troops, they, as a rule, knew little and cared less about the nature of the machinery by which this end was effected. Up to the year 1858 there was no general work in the English language treating on this subject as a whole, and it was due to one well known to the service, Brigadier-General Lefroy, of the Royal Artillery, then employed at the War Office, that Lord Panmure, in order to supply so glaring a blank in military literature, appointed me to the duty of writing a work on the organization and administration of our army.

Imperfect as was the performance of my task, it had, I may flatter myself, the effect of drawing attention to an all important question, and to be the precursor of many more valuable works on the same

subject, and I hope you will forgive me if I quote my own words as a preface to the immediate matter of my lecture:*—

"Any one who will carefully consider the organization and constitution of a military force, and reflect upon the ever-varying position of an army, must recognize the vital importance of an effective system for the supply of the soldier's wants; and when it is further considered that the military administrator has always a double duty to perform, the one towards the army, the other towards the state; that he has to maintain a judicious balance between the just wants of the soldier and the interests of the public,—keeping in view the necessities of the one and the capacities of the other,—it will be allowed that this branch of the public service is deserving of more appreciation, and calls for a higher degree of attention and study on the part of military officers, than has hitherto been bestowed upon it in this country.

"A glance at a soldier's life will show how in every stage of his career he is brought under the immediate influence of administration; how it adopts him for its own from the hour he enlists as a recruit to the last moment of his military existence; it trains him in youth, it supports him in manhood, it comforts him in age; it watches over him at home and abroad, in peace and in war, and follows him through the varied scenes of his life, in garrison and in camp, on the march and in the bivouac, on the battle-field and in the hospital. To the cares of administration he owes the clothing he wears and the food he eats, the arms he wields, and the bed he sleeps on; administration at length conducts the maimed and worn-out soldier into his peaceful and honourable retirement, and performs the last offices over his grave.

"Be the agent what he will, a cabinet minister or a clerk, a general or a commissary, each has his allotted task, and each performs his function in the great military machinery, upon the proper working of which, the efficiency of the army and the comfort of the soldier so materially depend.

"And yet, while administrative labours pervade every portion of the military body, presiding at its birth, watching its growth, maintaining its health and strength, facilitating its movements, supporting its operations, ever active, vigilant, and provident, they are so unobtrusive in their nature, as to be scarcely noticed amid the brilliancy of military action; and few are able to recognize in the pageantry of peaceful armies, or through the smoke and glare of battle and amid the shouts of triumph, the silent workings of administration, or to mark how materially they have contributed to the success of arms and to the fruits of victory.

"Certainly examples are not wanting to satisfy our military officers that so far from a study of administrative duties being beyond the province or beneath the notice of a soldier, it is a branch of knowledge which cannot fail to prove useful to him in any position in which he may be placed, and that it is essentially requisite for those who aspire to the command of troops or the conduct of military operations on an extended scale, that they should not only understand the principles, but be familiar with the details of the duties connected with the finance, the supply, and the account of the army. An inefficient commissariat may frustrate the best military projects; but a general ignorant of commissariat duties may equally destroy the most admirable administrative arrangements by his inability to estimate the difficulties or facilities attending them; at one time expecting impossibilities, at another exaggerating obstacles; rash and timid by turns, and always incapable of appreciating at their proper value the extent and the effect of administrative exertion.

"Cæsar, Napoleon, and Wellington,—three names identified with ancient and modern military genius,—have left us in their writings many proofs of their indefatigable devotion to administrative duties. Cæsar's genius, supported by unlimited political and military power, overcame difficulties which to modern armies would perhaps appear insuperable; Napoleon, though his despatches show the vital importance which he attached to a well-organized administrative department, and

* "Treatise on the Organisation and Administration of the British Army." Longman and Co.

how anxiously he laboured to create such a body, did not live to bring his plans to maturity, but left it to his successors to construct from his materials the most perfect system of military administration which can be found in Europe; Wellington did perhaps more than either, for with limited powers, and in the midst of all the confusion of a stupendous war, he improvised out of the most incongruous materials an administrative service which became the envy, and, in some respects, the model of his adversary; and there was no portion of this machinery which was not the result of his study and practical experience.

"The knowledge so acquired was never forgotten, nor did he ever, as many general officers do, consider the minutiæ of administrative duties beneath the notice of a soldier; on the contrary, there was no detail too complicated or too trivial for the grasp of his great mind. He had mastered alike the highest questions of finance and the simplest arrangements connected with the distribution of supplies; and while conducting one of the most important wars on record and personally performing the diplomatic, military, and political duties which it involved, he could find time to deliberate on intricate financial negotiations and to decide upon the composition of a ration.

"Such examples are surely worthy of imitation. No soldier can find it uninteresting to trace the steps which led our great generals to victory; he will find those steps not alone upon the broad road of military prowess, but often in the silent and unobtrusive paths and bye-ways of administration; he will learn to appreciate these services as he finds how intimately they are connected with that spirit of discipline which is the best guarantee for military success; and convinced of this truth, he will study with interest the means by which armies are maintained in efficiency, health, and comfort, and enabled to meet the ever-varying contingencies incident to military service."

It must be fresh in the recollection of many of my audience how, during the first year of the late war with Russia, as each day brought intelligence of fresh disasters, the wail which rose through the length and breadth of this land gradually swelled into a cry of indignation, and a stern demand for retribution. English men and English women read with grief and horror how our gallant soldiers were dying for want of the necessaries of life; marching to their posts on bitter winter nights with shoeless feet, shivering in the trenches with only rags on their backs, returning to their camp to seek shelter from the cruel weather in a rotten tent, to sleep on a bed of mud, and to find food—when they did find food—without the means of cooking it. Many of these details lost nothing in the telling, but there was enough truth in them to justify the public indignation, since it is but too well established that, while in the whole Crimean campaign less than 5,000 officers and soldiers fell by the hand of the enemy, upwards of 16,000 sank under disease and privations, of which a large portion might have been traced to preventible causes.

Perhaps there is no species of human suffering which more directly appeals to our sympathies than that arising from want of food, and as it was universally known that the Commissariat was the department charged with supplying the troops with food, it was upon that branch of the service that the popular indignation mainly fell for its alleged failure in the performance of its principal duty. It is not my intention here to defend the service to which I belong, or to offer excuses for short-comings in which I have to bear my humble share. I think calm reflection was not long in convincing the public that it was at fault in condemning the members of any particular branch of the service for being unequal to their duties. It was a faulty system, or rather the

absence of any system equal to the emergency, which caused the failure, and this defect applied not to one part or another, but to the entire machinery of army administration.

It was a heavy price we had to pay for military reform—a heavy price in treasure and in blood; but those disasters had one good result, they showed us the weak points in our military system; they convinced us that neither the devotion of officers nor the courage of soldiers can avail unless the auxiliary elements of success are perfect; it impressed upon us that there is no branch of the military service, however humble, that does not, in proportion to its efficiency, contribute directly to the honour of our arms; that, in a word, the weakness or the defects of one little wheel in the great military machine may suffice to stop the working or to derange the whole engine. Let it be admitted that the lesson has not been quite lost upon us; that the experience so dearly purchased has not been entirely thrown away. Within the last eight years great reforms have been effected, and if much remains yet to be done before our administration can be considered satisfactory, we may enjoy the satisfaction of knowing that the principles of a more perfect system are beginning to be admitted by those in high authority, and that their practical application is only a question of time. May that time arrive before we have again to meet the shock of war, for, as Sir William Napier has so truly said—

"War tries the strength of the military framework; it is in peace the framework itself must be formed."

And now I will proceed to illustrate, by a recital of our recent Commissariat operations in the field, the nature of the duties which devolve on that department, which I may, without undue professional *amour propre*, call the most important of all the somewhat vaguely and loosely called civil departments of the army—of the department whose duty it is to provide the soldier with all his material wants, under whatever circumstances he may be placed, in garrison or in camp, on the march or in the field, stationary or in movement, advancing or retreating, in health or in sickness; for although a branch of the medical department is charged with the duties of providing hospital equipment and diets, the main reliance of those officers must necessarily be on the Commissariat; if the Commissariat cannot procure and distribute supplies for the healthy, there is but a poor chance for the sick. The Commissariat command the market, they hold the money, they organize the transport, and on their means depends in all that regards supplies, the efficiency, the health, nay, the very existence of the entire army.

This is a great responsibility, and if that responsibility has not always been met, it becomes desirable to seek the causes of failure. Vauchelle, the highest European authority upon the subject, has told us that "the ignorant consider military administration a trade; but that enlightened men know it to be a science." I fear this knowledge is as yet not widely spread in our service, and *until* it is—until military administration is admitted to be a science, and reduced to practice on scientific principles, no expenditure of money on the part of the public, no degree of energy and intelligence on the part of agents, will suffice

to ensure the great object of administration, namely, a regular, systematic, and certain supply of the soldier's wants, under all possible circumstances.

Now I will tell you how we set to work in China: when, in 1860, an expeditionary army was sent out to resent the insult offered to our flag, by the resistance at the mouth of the Peiho river to our embassy, and the squadron which accompanied it. The force destined to march upon the capital of the Chinese empire was originally fixed at 6,000 men of all arms, but it gradually rose to a field force of 10,000 infantry, with two regiments of Indian irregular cavalry, three squadrons of the King's Dragoon Guards, and six batteries of Royal Artillery, making a total force of upwards of 22,000 men, with from 5,000 to 6,000 horses, and pack animals. In quoting the force at 22,000 men, I include non-combatants and camp followers of all kinds. A commissariat estimate is always necessarily in excess of a military one, for the latter counts by sabres or bayonets, to be brought into the field, while we count by the number of mouths to be fed daily. The whole of this force was collected in Hong Kong, where all preparations for its advance to the scene of action had to be completed. Hong Kong is distant about 1,200 miles from the mouth of the Peiho, where the landing was to be made; to convey the troops and all material of war was the duty of the Admiralty, who had ample means at their disposal for this purpose; it was not so easy to provide the means of enabling the invading army to advance into the interior of a country, of the characteristics and resources of which, we were all completely ignorant. Few, very few credible Europeans had any knowledge of that part of the Chinese empire, and though there was a mass of floating tradition and conjecture, there really was no reliable information to be obtained on the most indispensable points connected with administrative arrangements.

Whether there were roads, and if so, of what kind; whether there were canals, and if so where, and of what extent; whether there were horses, mules, camels, oxen; whether there were provisions of any kind; whether we were to advance through a fertile and cultivated district, or to traverse a desert; even whether we should meet with a friendly or a hostile population, all these questions so vitally important to lead to a correct estimate of the wants to be provided for, remained without solution, and as it was impossible to trust to chance for enabling our army to exist, and to move, it was determined that arrangements should be made for provisions and for transport, on the assumption that nothing whatever could be obtained in the *terra incognita* to which we were proceeding as invaders. The supply of daily food, for an indefinite period, sufficient for a force of above 20,000 men for cavalry and artillery horses, and for pack animals, was in itself no trifling undertaking, more particularly as the Indian troops had to be provided with articles of diet, the very names of which were unknown to a British commissariat.

It is true that officers of the Indian commissariat were sent to China for the purpose of providing for their troops, but it was soon found that the commissariat system of India differed so essentially in

principle and practice from that of the Imperial Government that the two could not be brought to act harmoniously together, and on the authority of the General Commanding, the Indian commissariat was sent back, and the supply of all the troops entrusted to Imperial officers. The established rations for European troops comprised no extraordinary articles, although it may be doubted whether soldiers on the march ever received so large and varied a ration, which included ale or porter, spirits, and lime juice; but the native troops required, in addition to goat mutton and rice or flour, with salt and pepper to flavour it, such things as dholl, ghee, turmeric, tamarinds, chilies, garlic, onions, and tobacco, and the commissariat were further required to keep opium for the use of such Indian soldiers as choose to purchase it. Colonel Wolseley, in his admirable narrative of the campaign,* says:—

"Providing for the wants of all Indians out of their own country, and at a distance from it, is a most difficult matter; the number and variety of races and caste render the feeling of such a collection as we had in China most puzzling, and adds immensely to the difficulties of commissariat officers. What one caste will eat another will almost sooner die than touch, so that in mixed regiments the arrangement necessary for their feeding on board ship was troublesome beyond measure.

"In preparing for the wants of a Christian force, in an unexplored country, the difficulties were great enough, but for a large body of Hindostanees our commissariat had more to contend with than ever, I believe, had devolved at any time upon that department before. It was arranged that all vessels proceeding north with troops should have provisions sufficient to last for several months for all the people intended to be on board. Doing this for the vessels intended for the natives of India was a complicated matter; many would not cook at all on board, so that a peculiar description of ration was required for them; and each caste required to pump in the water for their own especial use. Upon one occasion, just as a ship was reported ready for sea, and all had embarked, a man chose to turn Christian, so, in addition to the provisions then on board, supplies for the whole voyage were required for this one interesting neophyte. Imagine what must have been the daily labour of issuing the confusing rations of various sorts of peas, beans, bad butter, dried fish, and green chilies, &c., &c., to the fastidious heathen, and then the Government allowance of salt pork and biscuit to the solitary Christian."

The Chinese attached to the expedition in various capacities received only two pounds of rice daily. I need hardly remark that extraordinary preparations had to be made to meet the various wants for so considerable a force, and for a campaign of which the duration was so extremely uncertain. The resources of the surrounding places, far and near, had to be ascertained, and not only Europe, but India, California, Australia, and the Cape, had to be looked to for supplying our necessities, the question being not only where supplies might be found most abundant, but where they should be found cheapest, for let it be borne in mind that the commissariat has ever two-fold functions to perform—to provide for the soldiers' wants, and to economise the public money; to reconcile the most complete provision for the troops with the greatest possible amount of economy. The first consideration must ever be to supply the soldiers' wants, and to

* "Narrative of the China War of 1860." By Lieut.-Colonel Wolseley, Deputy-Assistant Quartermaster-General. Longman and Co.

effect this all other considerations must give way, but the next object of the administrative must be to produce the result at the least possible cost; and whenever two or more courses are open, the one easy but expensive, the other difficult but economical, the first by means of a convenient market close at hand, the other by a resort to remote market, hard of access, and beset with obstacles, the question of money, and no question of personal or professional convenience, or saving of labour, must decide the choice.

It is a comparatively easy task for a Commissariat possessed of an unlimited supply of money and abundant shipping, to accumulate large stores of all kinds in a seaport town, and to transmit them to the place of landing. It is when the troops do land and advance that difficulties begin, and that the great effort has to be made.

Now, when I tell you that the provisions and forage necessary for the force and camp followers who landed at the mouth of the Peiho amounted, for one day, to no less than 110 tons' weight, and that depôts had to be at once formed, not only at the base of operations, but on the line of march, while not less than three days' provisions had to accompany, and three days to follow, the troops, you will be able to form an idea of the quantity of transport which we had to provide in anticipation of the opening of the campaign. Bear in mind, also, that every horse, groom, or coolie added to the force for transport purposes, added so much to the weight of provisions to be carried.

But, in addition to this, no less than between 400 and 500 waggons, with about 2,000 horses or mules, were required to carry camp and hospital equipment, ammunition, warlike stores, and regimental baggage, all of which had to be provided under Commissariat arrangements.

And here I must stop to remark on the intimate connection necessarily existing between provisioning duties and transport duties, and the impossibility of enforcing the responsibility of the officer charged with feeding the troops, unless he have full and uncontrolled power over the means of conveying supplies.

To require one agent to collect and distribute provisions, while he is made entirely dependent upon another to provide him with the transport necessary for the performance of this duty, creates a division of responsibility which must weaken the hands of administration.

Yet such is the system prevailing in our service; nay more, not only is the Commissariat forced to rely upon an extraneous and independent corps for the supply of one of its most important wants, but this corps being a purely military one, cannot receive direct orders from Commissariat officers, and the interposition of a third agency, the Quartermaster-General's department, becomes necessary for the very first step towards obtaining transport. Under such a system the least want of concerted action must lead to inevitable failure, and it is unfortunately too notorious that concerted action between the different branches of the service, each of them having its own peculiar views and habits of thought and prejudices, cannot be always expected. The best proof that the system is bad is to be found in the fact that the necessities of

war at once destroy it, and that virtually the supply department then controls the transport. Thus in the expedition to the north of China the military train received instructions to act under the Commissariat; the purely military organization of the train to which I have referred made its subordination to a non-combatant corps difficult and hazardous, and it was only through the determination of the General Commanding to enforce this, and, I should add, ultimately to the good feeling shown by the officers of both corps, and their anxiety to further the public interest, that failure was avoided. As it was, however, the service could not have been carried on, but that the Commissariat organized its own independent transport; and this consisted partly of pack animals, for the procuring of which Commissariat officers were sent to India, Manilla, Japan, and the Chinese treaty ports, but also of a corps still remembered as "the Bamboo Rifles"—Chinese coolies, two of whom carry a load of one cwt., suspended from a pole borne on their shoulders for continuous periods, and at a very fair pace.

The notion of forming a transport from such an element first arose in the war of 1858, and was much ridiculed, the old European inhabitants of China prophecying that the coolies would desert or commit suicide rather than take part in an attack on Canton. This corps was raised, however, under the immediate direction of Sir William Power, the present Commissary-General in Chief, and "the Bamboo Rifles" embarked cheerfully to a man, landed with the troops, went coolly under fire to carry off the wounded, and when the city had to be escaladed, carried the scaling-ladders to the walls without flinching.

We raised about 3,000 coolies to accompany the expedition to Pekin; the fear of a long sea voyage, and their conviction that we should be repulsed, and that they would be taken prisoners and put to death with more or less ingenuity of torture, served to weaken their ardour for enlistment; but, on the other hand, a high rate of pay and the prospect of loot, which is very dear to the heart of a Chinaman, overcame their scruples, and they embarked, and rendered admirable service; they again went under fire with the coolness of old soldiers, and not only carried the scaling-ladders on the capture of the Taku Forts, but when these were found too short (a common failing with British scaling-ladders by the way), they supplied the deficiency by supporting them on their backs and shoulders.

This kind of transport has, however, one drawback: a coolie corps occupies much space on the line of march; requires a very strong escort; and is difficult to keep in order when the temptation of looting presents itself (on their return from Pekin many broke down from the weight of loot they carried in addition to their legitimate load); and they are apt to be seized with a panic on very slight grounds, and on these occasions they will drop their burden and bolt without hesitation.

Upon the whole, however, I think Chinese coolies would form an admirable transport corps; indeed, I am inclined to think that they would make better troops, if properly officered by Europeans in whom they could place confidence, than many of the Indian races now employed as soldiers. For garrisoning our tropical or unhealthy stations,

such as the Straits' settlements, or even the West Indies, I believe they would be admirably adapted.

I think I am borne out in my opinion as to the convertibility of Chinamen into soldiers by the facts that have lately fallen under our notice.

In 1861 an American, of the name of Ward, was authorized by the Governor of Shanghai to raise a force of Manilla men, Chinese, and rowdies of various descriptions, for the purpose of defending the approaches to that town from the predatory bands of the Taeping rebels. This experiment having been attended with some success, Ward was empowered to recruit a better class of men from the native population, to give commissions as officers to such qualified Europeans as would join the force, and to assume for himself the rank and dignity of a General in the Imperial service.

With this force, amounting to some 500 men, Ward achieved most important successes over the rebels, and did good service to the Imperial cause in 1862. Subsequently the contingent of General Ward was increased to some 1,500 or 2,000 men, who played no undistinguished part in the operations against the rebels, which were conducted under the command of Brigadier-General Sir Charles Staveley.

The intrepidity of these troops was most remarkable. Led by European officers, and stimulated by the presence of British soldiers, Ward's levies fought at the assaults of Khading, Tsingpor, Nangou, and Tsolin with the greatest bravery. Upon the death of Ward, at Nankin, the command of this force was conferred upon Lieutenant-Colonel (then Captain) Gordon, R.E., who converted Ward's raw levies into a well organised and thoroughly disciplined army, equipped with field artillery and a siege train. The strongholds of the insurgents were captured one by one, the rebels were everywhere dispersed and routed, and by the storming of Soochow, the power of the dreaded Taepings was finally destroyed. Under the leadership of Gordon, these Chinese levies were taught to believe that a battle meant a victory, and that under the orders of English officers the most difficult and dangerous enterprise would be attended with certain success.

Inured to hardships and privation, docile and tractable, regardless of danger, and indifferent to death, the Chinaman possesses in a far higher degree than the Indian, the best attributes of a soldier, and in physical power he is eminently superior to the sepoys. I must not overlook his further merit of being able to live, work, and fight upon a small quantity of the simplest food.

Our horse transport was created by the extension of a battalion of the military train into three brigades of 1,500 animals each, comprising horses, ponies, mules, and bullocks, with a proportion of four-wheeled waggons, and light Maltese carts, in addition to which we captured a good many mules and carts after landing at Taku.

The horse transport was officered by the military train, with the assistance of officers of the line, and worked by the non-commissioned officers and men of the train, supplemented by about 1,500 Indian, Chinese, and Manilla men to act as drivers and attendants; this would

give about 10 native drivers and 30 animals to each private soldier of the train.

It was at one time contemplated to throw a cordon across the Shantung Promontory, and thus cut off a large quantity of transport animals, which are very abundant in this province; but this scheme, which, as it afterwards proved, would have answered admirably, was abandoned.

The whole of the Land Transport was under the direction of the Commissary-General, who, without interfering with the discipline, detailed it for the various services required to be provided for; so much for reserve ammunition, so much for camp equipage, so much for hospital use, but whenever it was no longer required for these purposes, it reverted to the Commissariat, and became available for the carriage of supplies, and keeping up the depôts of provisions.

It has often been proposed that each regiment and corps should have its own complete and exclusive transport, but the great objection to such arrangements, independently of the division of responsibility which would result from it, is the expense; for during a considerable portion of a campaign such transport would be unemployed; the horses and waggons necessary for a force while on the march would become an incumbrance when in quarters or otherwise stationary, and the Commissariat transport would be additionally taxed for providing forage for horses, and food for men, who were really no help to the army, but would be only eating their heads off."

It is for this reason that I advocate a general transport for the whole army, portions to be detached as required for different services, but all to be under the control of the responsible supply department. I don't wish for a moment to claim such control for the Commissariat, or for any one other department over another. It matters little, provided the qualifications for organizing and employing transport are equal, what you call the officer at its head, but what I contend is, that whoever is at the head of the transport, should be the man held responsible for the troops being supplied with provisions and their other various wants.

Our transport in China, formed of such incongruous materials, was a little unmanageable. The mules obtained from India were perhaps the most useful there, as they are almost everywhere else, as pack animals, for heavy work. Bullocks answered very fairly, drawing heavy loads over bad roads. The most difficult things to deal with were the Japanese horses. I had been employed in collecting these animals, and a very interesting mission it proved. In those days the Japanese ports had only been recently opened to Europeans, and the capital of the Tycoon was still a closed book to all but a few diplomatic agents. My negotiations for permission to export 3,000 horses were lengthy and difficult, but certainly very amusing, from the novelty of the scenes to which I was thus introduced. Japanese horses have, I think, every defect to which horseflesh is heir. They are stumbling and leggy, with no shoulders to speak of, and sloping hind-quarters. From their being put to work very early, it is rare to meet with a sound horse five years old. They are very difficile too in their diet, living principally

upon boiled peas, and never eating their grain uncooked. You would imagine that pea-soup was not an exciting food; but however this may be, there is nothing I ever met with in equine life that comes up to the viciousness of a Japanese horse. Among themselves they are well enough, but their horror and hatred of foreigners is something indescribable, and their antipathy was probably aggravated by the necessity I was under of teaching them to wear iron shoes instead of a straw shoe, which is their ordinary wear, and my efforts to make raw grain palatable to them. However, about 3,000 of these animals were procured. There was an unaccountable delay in sending shipping to remove them. When ships did at last arrive, they were not fitted, and I had to get Japanese carpenters to undertake this peculiar, and to them quite novel work. The people sent over as horse attendants were afraid of their lives to go near the horses when they were embarked, their tempers not being improved by board-of-ship life. The weather was stormy. One horse getting loose, set all the others mad; and on the whole I fear there was not a good account of my purchases by the time they reached China. One ship which left Japan with 300 horses put back after 20 days. She had encountered bad weather, during which some of the horse-fittings on the main deck had given way. The horses broke loose, and fought furiously. The attendants were afraid to go near them with food or water; and when the ship came into harbour only 70 horses survived, and of these one-half were so mutilated and wounded that they had to be destroyed. Before one-half the horses purchased in Japan could be embarked, peace had been concluded, and the rest were left in their native land. Of those that reached China very few survived the campaign. Whether they suffered from home sickness, or missed their favourite food, or could not bear the contact of foreigners, I know not, but they almost all pined and died—vicious to the last kick.

The total average strength of our transport in China was 4,500 men, and 2,500 animals, inclusive of the coolie corps; but the numbers estimated as necessary for the ordinary wants of a field force of 9,000 or 10,000 men is about 5,000 horses, mules, or oxen, 2,500 men, and 1,000 waggons or carts, and such an establishment should suffice for moving with an army, and providing it within a distance of never less than 12 miles from the base of operations. What enabled us to carry on the operations in China with so much less transport was, that we had, after the landing at the Taku forts, the use of the Peiho river, upon which the Commissariat had organised its own water transport by means of junks, and which afforded an immense relief to the land transport. The co-operation of the Royal Navy was likewise of great use in the carriage of supplies, though there, again, the impossibility of the Commissary-General exercising any control over Naval Authorities frequently led to inconvenience and waste. It is quite as important that a Commissariat should have its own independent water transport as that it should control its land transport.

All our preparations being completed, the army embarked at Hong Kong in the end of May, 1860, partly in ships of war, of which, including gun-boats, there were 70, and partly in hired transports, of

which there were 120, but it was the 8th June before the fleet got fairly under weigh, and with all means and appliances sailed for the Gulf of Pechili. Colonel Wolseley was quite right when he said:—

"England has never before opened a campaign with such a well-organised or a more efficient force. Nothing that could add to the health or comfort of the men was neglected, and all that talent or ability could do, to render an army perfect, was provided for."

It was arranged that the British fleet should rendezvous in Talien Wan Bay, on the eastern coast of the Gulf of Pechili, when the first Commissariat depôt was formed, and called Odin Bay, while the troops were landed at different points on the coast. Here the people proved very friendly after the first shock of finding themselves in contact with the barbarians was over, and we had no difficulty in purchasing transport animals and cattle in large numbers, and at very reasonable prices. Here we were detained for some time, in consequence of the French not having completed their arrangements, and on the 26th June our fleet again weighed anchor and sailed with a fair wind for the general rendezvous off Peiho, leaving a force of about 1,000 men, Europeans and natives, at Odin Bay, where hospital accommodation for 500 sick had been established.

On the 31st the disembarkation of the troops at Pehtang took place. The 2nd brigade of the 1st division, with a 9-pounder battery and a rocket battery, forming the landing party, not having been opposed, bivouacked under the walls of the fort which proved to have been evacuated by the garrison.

Our troops were provided with three days' provisions, which they were supposed to carry in their haversacks, but they were tolerably independent of the Commissariat, the pigs and poultry found roving about the town of Pehtang, furnishing them with ample food as well as sport; but the scarcity of water, which had to be brought in boats from about four miles up the river, was severely felt by man and beast.

Our allies had such inadequate means of disembarking troops that our stay at Pehtang was protracted until the 12th August, when the troops marched for Sinho, a small fortified town on the banks of the Peiho, and in rear of the Taku forts. The approach to Sinho was over a narrow causeway, and the ground on each side was very deep. A good deal of difficulty arose with the transport, even the artillery found it very hard work to get along, and several ammunition waggons stuck, and obstructed the line of march for some time. This is one of the great objections to wheeled vehicles for army transport; it has been urged that waggons can go wherever artillery can, but it can rarely happen that baggage waggons are so well horsed as artillery, and from the nature of their loads they are much more apt to break down.

I remember hearing an old Peninsular officer say, that had our army been defeated at Waterloo, their retreat upon Brussels would have been rendered almost impossible by the number of broken down or abandoned baggage waggons that encumbered the road. There are, of

course, some bulky stores which can be conveyed in no other manner, and a certain number of wheeled conveyances are indispensable with every army, but for a short and rapid campaign, I should like nothing better than thoroughly organised horse or mule transport for all purely Commissariat purposes. In giving the preference to pack animals over wheels I am aware that I oppose many high authorities, and if I could always rely upon such waggons as do most of the carrying business at the Cape of Good Hope, and if time were no paramount consideration, I should, perhaps, waive all objections; but everything in the science of modern warfare tends to render active operations short and rapid, and there are, after all, only few articles indispensably necessary to the soldier on the march which might not, with proper arrangement, be reduced to the bulk which a pack-horse would carry. I am not sure, though I speak on this point with less confidence and subject to correction, that well appointed cacolets and Indian dhoolies might not with advantage supersede the clumsy and cumbersome ambulance waggon for the conveyance of sick and wounded.

I dare say you all remember the old story of the member of Parliament who, in the time of the Sikh war, horrified the House by quoting from a private letter which he had just received, a description of a sanguinary battle that had taken place. After detailing the slaughter he added, "but this is not the worst, for the wounded were left on the field till late at night, when a number of ferocious dhoolies came down and carried them off,"

Now the ferocious "dhoolie" is perhaps the most comfortable of all vehicles for the conveyance of a sick or wounded man, and with sufficient and trained bearers would, in my opinion, prove preferable to any other mode of conveyance. In China, where every coolie is accustomed to carry such burdens, the dhoolie would have answered admirably. But it is very difficult to lay down general rules with respect to the description of transport necessary for an army since this must necessarily depend upon the nature of the country in which operations are conducted, and in nothing is a Commissariat officer's ingenuity and ability more taxed than in the means he takes for adapting the resources of the theatre of war to the immediate wants of the force to be provided, and grafting local materials and usages upon our own institutions.

The pack-saddle, the harness, and the cart to which an animal has been accustomed should not be lightly rejected because of their apparent defects, and it will always tend to remove difficulties in a strange country, if we show a disposition to concede something to its peculiar customs, however much at variance with our own, or even what may appear the stupid prejudices of man and beast.

But to return to China. The first blood spilt in the Chinese campaign was drawn on the approach to Sinho, around which large numbers of Imperial troops were collected, and where we formed a depôt of provisions calculated to last ten days; from thence the troops advanced upon Tanghoo, an entrenched village in the bend of the Peiho, where considerable resistance was offered, but which was assaulted and carried on the 14th August by the allied forces. Some time was

passed here in preparing for the assault of the Taku forts, and the whole transport of the army was busily employed in collecting supplies and carrying materials for the bridges about to be constructed over the river.

It is beyond my province to dwell upon the details of the military operations which resulted in the capture of the Taku forts, and the subsequent capitulation of all the strong positions on the Peiho, as far as Tientsin, including that city itself.

A large depôt of provisions was formed at Taku, which a regiment of infantry was left to garrison, and on the 23rd August the army advanced on Tientsin, part being conveyed by gunboats, a part marching up the left bank of the river, and another marching up the right bank. A very large portion of the Commissariat stores was conveyed by water, with the view of relieving the land transport, but the columns of *impedimenta* by shore was still very large, and there was an intermediate line of coolies jogging along cheerfully with the victorious army, and apparently enjoying the triumph of the barbarians.

The march to Tientsin only occupied two days, and the first duty of the Commissariat on arriving there was to make preparations for a regular supply of food. With this object, negotiations were entered into with the Imperial authorities, since, however abundant provisions might be, these could only be obtained for the use of our troops, either by force, or through the local officials, and according to the practice of our service, and the true principles of administration, the latter course was adopted while it was open to us; but in a very few days, diplomatic relations between the English and French agents and the Chinese Commissioners were broken off, and orders were received for the advance upon Pekin.

We were now about to plunge into a complete *terra incognita*, and from all we could learn, orders had been given to sweep the country before us of all provisions and transport; the river above Tientsin was supposed only to be navigable as far as Ho-si-woo, and the district was described as a perfect desert, yielding not a blade of grass or a drop of water. To make matters worse, on the evening before the march, all the native drivers whose carts and animals had been hired at Taku, and on the line of march, acting under orders of the Chinese authorities, deserted in a body, taking their animals with them, and they succeeded in evading pursuit.

On the 13th September the army reached Ho-si-woo, a large town of some commercial importance. So far from the rumours which had been carefully spread in Tientsin as to the barrenness of the land being correct, the whole district through which our troops passed was covered with thriving crops of maize and millet, while the villages plentifully scattered over the plains consisted of well built houses, prettily surrounded by gardens and orchards. For the first part of the way nothing could exceed the friendliness of the natives, who offered to provide out of their small means whatever might be acceptable, but as we got further, the character of the population changed; fear and distrust took the place of confidence, and when we reached Ho-si-woo, we found it almost completely deserted. A Commissariat depôt and

transport establishment were at once established at Ho-si-woo, which was occupied by an infantry regiment and a detachment of cavalry, while the bulk of the army advanced to Matou, where it had been arranged that negotiations with the Chinese authorities should be renewed.

The river was, it appears, navigable beyond Ho-si-woo, as far as Tangchoo, whence a canal communicated directly with Pekin. It was there that our diplomatic agents had agreed to meet the Chinese Commissioners, and they were accompanied by Colonel Walker, Assistant Quartermaster-General, Assistant Commissary-General Thompson, who proceeded to arrange about supplies, and a few troopers of the King's Dragoon Guards, and of Fane's Horse. There were certain indications on the route to Tungchow, which should have rendered this little party very careful. The crops had been carefully cut or destroyed, and large bodies of Chinese troops hovered about, retreating slowly as the diplomatists and their escort advanced; still no apprehension appears to have been excited, although Mr. Parkes, then Consul at Shanghae, prided himself upon his intimate acquaintance with the habits and character of the Chinese; in this instance he proved to be mistaken.

The French had also sent some officers to Tungchow, and the first act of treachery was committed upon a French Commissariat officer, who was cut down while discussing an arrangement for procuring provisions. This officer called for assistance when attacked, but was deliberately murdered in the presence of our men. Colonel Walker seeing how matters stood, and that it was hopeless to contend against such odds, gave the order to his party to gallop into camp for their lives, and in spite of a fire that was opened upon them, they escaped, Assistant Commissary-General Thompson and one trooper only having received slight wounds. The unfortunate men who, on the strength of Mr. Parkes' representations remained behind, were, as you may remember, taken prisoners, and the majority of them tortured to death in a Chinese prison.

These acts of treachery, although the worst was not known, led to our immediate advance. The enemy, estimated at 20,000 men, were driven before us with large loss, and we did not again halt until within a few miles of Pekin, where we formed a camp, and awaited the arrival of our siege train, without which Pekin could not be assaulted. In the meantime the Commissariat were busily engaged in bringing up provisions by means of regular flotillas of junks which had been seized on the river, and a fortnight's supply was speedily collected and kept up at Tungchow, while another field depôt was formed near the advanced camp at Palechow, and left under charge of a strong escort, when the force advanced to meet San-kolins forces to the north of Pekin.

Excellent relations were established with the Chinese in this vicinity, and the effect was that an admirable market of fruits and vegetables, fowl, fish, and meat, was established at very reasonable rates. Our allies, who are more prone on active service to seize than to purchase, found out their mistake on this occasion, since Chinamen would travel any distance to avoid meeting with French troops, while they entered

our camp with the most complete confidence, and competed for our custom with the eagerness of London tradesmen.

Our coolies here were difficult to control. They seemed to look upon their countrymen as their legitimate prey, and it required all the arguments of the Provost Marshal, from whipping to hanging, to convince them that robbing defenceless villagers was no part of British warfare.

Too much importance cannot, in my opinion, be attached to a conciliatory policy towards the non-fighting population of an invaded territory, and no penalty can be too severe for those who damage our national character by acts of oppression and violence towards those whose goodwill may be of such vital importance to the well being of an army; and here I am once more tempted to quote my own words, because I cannot more emphatically express what I feel very strongly:

"The unarmed citizen should be taught that the invaders of his country do not war with him, and that while he displays no hostility, he is entitled to claim the protection of his nation's enemy for his person and property. In return for such protection he is bound to contribute towards the maintenance of the invading force, and it is not until he shows himself determined to adopt the less prudent, though more patriotic course of refusing to furnish supplies to the enemies of his country, and attempts to remove or to destroy them, or to dissuade others from contributing, that he must renounce his claim to indulgence, and that his property becomes the lawful prize of the enemy.

"But even amid a hostile population a conquering army should exercise its power with every possible regard to justice. Fair treatment may reconcile a people to the presence of a conqueror, and induce it to submit to superior strength. No effort should be left untried to produce such a result, since a resort to force, although it may provide for immediate wants, inevitably destroys the sources of supply.

"The stern rules of war justify the exaction of all the resources within its influence; it is for administration to render these exactions as little oppressive as possible when dealing with a class of people which, as a rule, is the most innocent of the causes of war, the most exposed to its ravages, and the least benefited by its results. In proportion as tact and moderation are displayed by the agents employed in levying supplies upon the population, so will the resources of the country become available and productive. Violence and wrong will convert the peaceable peasant into a desperate and implacable foe; conciliation and fair dealing may make him, if not an ally, at least a profitable neutral. Interests far beyond the hour may be involved in the action of military administration under such circumstances, and the seeds of rancour or goodwill sown to-day on the scene of contending armies, may bring forth fruit to influence the destinies of nations long after the combatants themselves have ceased to struggle."

During the whole period that our troops were on the march, or encamped between Tientsin and Pekin, they were kept supplied with all kinds of provisions as regularly as they would be in an established garrison. The Commissariat staff corps, then but recently organized, did admirable service wherever the troops halted. Field-ovens were at once constructed, and bread was baked; cattle was slaughtered, and meat prepared; while the system of distribution of all provisions was carried on in the most systematic manner. Every soldier is in some respect more handy and helpful by the training he acquires in our camps of instruction, but I doubt whether any corps benefits so much by camp training as the Commissariat staff corps, and if ever I should again be employed in the field, I should feel every confidence

that in all that regards the duties of that corps, no cause of complaint and no apprehension of failure would arise. I only wish that equal confidence would exist with regard to the transport service, upon which a Commissariat officer is as much dependent as upon the agents for conducting the provisioning duties, if not more so.

A kitchen upon wheels, the invention of Captain Grant, was sent out from England to accompany the expedition, but owing to some mistake it remained at Hong Kong, or on board ship, and the means of testing its value were lost to us. It would certainly be a great convenience if a body of troops marching out could throw their ration of meat into a boiler accompanying them, and find their dinners ready cooked when they should halt, but I fear that bad water would interfere with the culinary process. In Hyde Park, where this cooking waggon was tried some years ago, it proved most successful, but then the late Monsieur Soyer sat on the box, armed with sauces and condiments, and superintended the culinary process, which may account for the excellence of the soup.

A compressed forage, the invention of M. Julyan, lately an officer in the Commissariat, proved of the greatest use, not only as being extremely palatable to the horses, but in an enormous saving of transport. A good deal of difficulty, however, arose from the variety of diet required by the variety of animals, and again of the varieties of tastes and habits of each; and I feel convinced that the falling off and deaths among many Japanese horses was entirely owing to the loss of their accustomed pea-soup.

With the advance on Pekin, the looting of the Summer Palace, and the subsequent capitulation of the capital, you are all acquainted.

On the 7th and 8th November, having obtained all the objects for which the war was undertaken, the army marched back to Tientsin, a flotilla of boats keeping pace with the line of march upon the river; and by the middle of November, when the cold weather had set in with unusual severity, the whole army, with the exception of the brigade left under Brigadier Staveley to occupy Tientsin and Taku during the winter, embarked for the south of China.

I have now concluded my very imperfect and meagre account of the Commissariat operations during this short campaign. I may state that I intended my remarks rather as illustrations of the character of Commissariat field-service than a description of what was actually undertaken and done. I had intended following up the subject by a more detailed narrative of Commissariat operations during the late war in New Zealand—operations of far greater magnitude, and attended with far greater difficulties than had to be overcome in China—but I have already trespassed too long upon your time, and will only, in conclusion, beg of you to accept my best thanks for the patience and indulgence with which you have listened to my remarks.

Evening Meeting.

Monday, June 4th, 1866.

CAPTAIN J. H. SELWYN, R.N., in the Chair.

NAMES of MEMBERS who joined the Institution between the 21st May and 4th June, 1866.

ANNUAL.

Webster, Hamilton, Capt. H.M. 8th Beng. Cav. 1*l.*
Warde, W. J., Major H.M. 8th Beng. Cav. 1*l.*
Wright, Daniel, Asst.-Surg. Residency, Nepaul.
Wilson, H. B., Lieut. 71st Highland Light Infantry, 1*l.*
Brownlow, E. F., Lieut. 71st Highland Light Infantry. 1*l.*
Gardner, R. Ogilvy, Lieut.-Col. H.M. Madras Army. 1*l.*
Meane, John, Staff Surgeon. 1*l.*
Godman, A. F., Captain 6th Carabiniers. 1*l.*

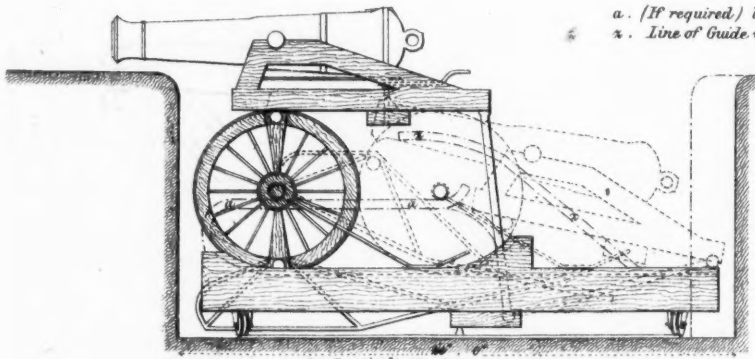
MONCRIEFF'S METHOD OF MOUNTING GUNS WITH COUNTERWEIGHTS, OF USING THEM IN GUN-PITS, AND OF LAYING THEM WITH REFLECTING SIGHTS.

By Captain A. MONCRIEFF, Edinburgh Artillery Militia.

THIS invention, nearly as stated in the following description, was submitted by me to General Sir Richard Dacres at Dublin in 1858, while I was under his command, and a description of it was forwarded by him, with his recommendation, to the Secretary of State for War at that time. On the 30th October, 1858, I received a letter from the Secretary to the Ordnance Select Committee, requesting me to send my drawings and models, but was unable to comply with the request at that time. My invention was again submitted to the Government on the 3rd March, 1865, and on the 12th April I received a communication from the Director of Ordnance, informing me that the Government declined to entertain the subject further, as the Ordnance Select Committee reported unfavourably of it, on account of four objections which they stated in their report, and to which I shall afterwards refer. I have now much satisfaction in submitting my invention to this Institution, believing that the subject is of some importance.

The precision and range of modern ordnance, and small-arms, obtained by the introduction of rifling and other improvements, have materially increased their power, while means for the protection of the guns, and the detachments serving them, remain much as they were. Casemates of various constructions afford protection to the artillery, but at the expense of increased works, and of limiting most objectionably the range of fire. The iron turret alone affords protection to the men, with free range to the gun; but it is an expensive arrangement, and only applicable to ships or permanent works at im-

Sketch of one arrangement of Moncrieffs Protected Barbette Carriage as placed in one of his proposed Gun Pits, with a 95 Cwt. Gun.



a. (If required) line of Guide Rail
x. Line of Guide when radius Bar is not used

Diaⁿ 18'. 6" with shortened Carriage

Scale

12 0 1 2 3 4 6 10 15 20 FEET.

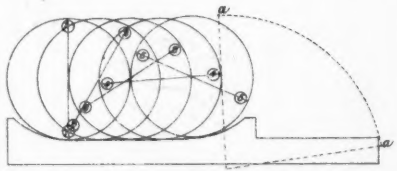
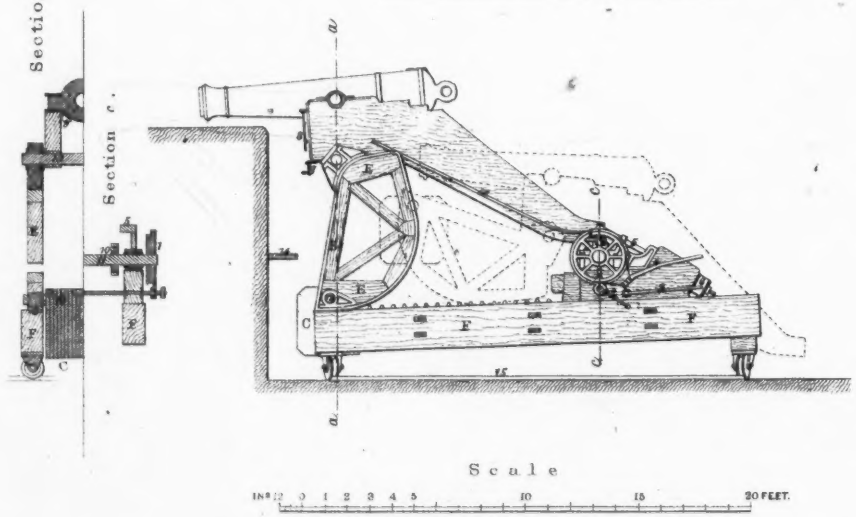


Diagram shewing the position of the Axle of the Carriage at five points 1. 2. 3. 4. 5 descending. And also the simultaneous position of the Axle of the counterweight at 1. 2 3 4. 5 ascending. a. a. The line on which the end of the radius Bar (which supports the back of the Carriage) descends.

J. Johnne

Sketch of an ordinary 95 Cwt. Gun mounted according to one arrangement of Moncrieffs Protected Barbette System, Jan^{y} 1865.



F. *Frame*
C. *Counter weight*
E. *Elevators consisting of wro.^{t} Iron Frame filled in with Wood*
1. *Purchase & Brake Wheel*
2. *" Handle*
3. *Check*
4. *Brake*
5. *Holding Bar*
6. *Tensil Buffer*
7. *Handle of elevating Screw*
8. *Tangent Scale*
9. *Reflector*
10. *Great Pinion*
11. *Purchase Axle*
12. *Counterweight Axle*
13. *Axle of Carriage*
14. *Step*
15. *Racers*
16. *Guide Rail*

J Jobbins.

portant points. Where a few guns are required to command a large area—such as those in coast batteries, on salient angles of fortifications, or on small detached works—such guns must still be mounted *en barbette;* thereby necessitating the exposure, while loading, of a portion of the gun detachment. It is obvious that, with the precision of fire that can now be obtained, a gun so mounted would be served at a great sacrifice of men, whilst the gun itself is exposed on every side. The object of my invention is to give all the advantages of a barbette battery without exposing either the men or the gun; in fact, to obtain the range of the turret by a plan that is neither expensive nor unwieldy, and which can be used in almost any situation in which defensive artillery is employed.

Description of the Carriage.

This carriage is mounted on a simple frame, consisting of two longitudinal beams which traverse in the usual manner on a pivot and racers. It consists of, first, the gun-carriage proper; the cheeks being elongated into a double trail, which, during the recoil, is supported by an axle resting on the after-part of the frame, or it may without elongation be supported by two guide rails, or by iron or wooden beams from the bottom of the frame, hinged at both ends; and, second, of two curved elevators joined together by two axles, one of which supports the carriage, and the other a counterweight. For guns of position the wheels may be used for elevators, and the carriage formed with a block trail. In this arrangement the recoil is stopped by the travelling rails on the frame being made with an incline or curve, rising at the rear, and each wheel fitted at two opposite points of the circumference with bushes to receive the axles of the carriage and of the counterweight. This arrangement has the advantage of making a siege gun an engine that can travel on its own wheels, and, if required, it might be brought into action with the gun carriage axle in the centre of the wheels. When in the firing position, the gun overlooks the parapet or brink of the gun-pit, and is in stable equilibrium. The under part of the trail is curved, so that the gun on being fired recoils for a short distance parallel to its own axis, and then descends into the loading position out of fire. The elevators when round are mounted on a curved rail; when the rail is flat they are curved, so that the force of the recoil is gradually met by resistance, rapidly increasing as the gun reaches its lowest position, where it is held by a check. When the gun is loaded and ready, the check is withdrawn, and it rises by means of the counterweight, or is raised with little labour into the firing position by the means provided. In other words, the energy of the recoil is stored up in the counterweight, and converted into actual energy for raising the gun into position. The inertia of the counterweight is very small at the moment of discharge, from the slow rate at which it at first moves in comparison to the gun, whilst the leverage which it may be made to exert at the end of the recoil is very great.

Fittings.

The carriage may be fitted with friction apparatus, two tensil buffers to stop the forward motion, and two common buffers to stop extra recoil or curves on the rail may be made to give the same effect.

Also a purchase for raising and lowering by means of a rack and pinion, or common tackle may be found on service to be most handy, and quite sufficient. In addition to the ordinary fore and back sights, the gun is fitted with a small reflector under the breech; in front of this reflector, and nearly under the trunnions, is placed a long hinged back sight, graduated with the ordinary tangent scale; by this means the gun can be accurately laid without exposing a single man of the gun detachment. When the reflecting sight is used, the elevating screw is worked by a handle in front of the carriage. The circular rail or racer is fitted with a scale, read by a pointer fixed to the frame. This scale corresponds with one drawn through middle range on a chart of the ground round the battery, and enables the officer almost to complete the traversing while the gun is lowered. These fittings, as well as the other arrangements, can be used, altered, or dispensed with, according to circumstances. It will be observed on examination that the principle on which the carriage is constructed is capable of an extraordinary amount of adjustment. By a slight alteration a spare or disabled gun can be made to do for the counterweight; a tray for stones, spare shot, pig-iron, or any heavy material can also be used. By another alteration, the gun can be made to take any amount of depression for plunging fire. The amount of elevation and depression of the carriage, the length of the recoil, in fact, almost every condition, can be altered by changing the curves and proportions of the elevators, and other parts; and at the same time the gun can be worked without any fittings beyond the simplest appliances of a battery.

Advantages of this mode of Mounting Ordnance.

I shall now refer to some of the advantages of this mode of mounting ordnance. As the main object of this invention, besides economising labour, is to keep the gun detachment and carriage absolutely under cover, and the gun also (except at the moment of firing), it is scarcely necessary to add that it must be mounted either below the level of the ground or of a raised parapet, and that it is peculiarly well adapted for circular gun-pits (which, as yet, have not been used for artillery), as the largest guns can be mounted on my carriages in circular pits about 20 feet in diameter.

It will be noticed that the principle is applicable to any size of ordnance, from a field gun to the largest that is made, although more so to the latter. The parts are simple and portable, and can easily be taken to pieces, and any part of the carriage which may be injured in action can be replaced. In the event of this carriage being used for

embrasures or casemates, front pivoting can be resorted to without the risk of shaking the fastenings, as there is no shock conveyed through the carriage to the pivot as in the case of ordinary traversing platforms; and the absence of friction in resisting the recoil eases the whole strain on the carriage and platform, and allows lighter materials to be used. Large guns can be mounted from the rear without the aid of a gun. The gun can be loaded and traversed out of fire, and not one of the gun detachment is necessarily exposed even in laying it. On a front not exposed to enfilade, and where lateral range is not required, more guns can be mounted than the same space could possibly carry with embrasures. Large guns are worked with a smaller detachment more rapidly than the dwarf traversing platform gun now in use. In firing with the usual sight at a moving object, such as a ship passing rapidly in front of a battery, the time that must elapse between aiming and firing has to be guessed and allowed for. In such a case my arrangement has this advantage, that the gun can be fired while the aim is being taken.

In a battery of gun-pits mounted with my carriages, the guns could, on an emergency, open fire alternately over one another, without an echelon arrangement; this result cannot be obtained by any other method, and will make possible several arrangements in fortification hitherto impracticable. Gun-pits are well adapted for covering the front of a permanent encampment. The room occupied by each gun-pit is so small that it is not much exposed to vertical fire, the more so as every mark of its position can be removed. A thin screen of brush-wood near the gun would prevent an enemy from seeing whether it was down or up.

These carriages in gun-pits can be placed in situations covered by other batteries, which no guns otherwise mounted, could occupy. While the fire of an enemy was engaged in silencing the guns on regular and visible works, gun-pit howitzers could remain unseen and secure until they might be required to repel a sudden attempt to storm, as, from their nature, they can be brought into action at any moment, although previously concealed from view. Such a reserve at Fort Fisher in the late American war would have altered the conditions of its capture. The fire directed on that fort was so heavy that those guns which were not disabled had to be shunted out of fire, and were to all intents the same as disabled. The place fell before they could open fire on the storming party.

For permanent coast defences, or, in fact, for any position in which barbette guns are used, my method is available. The enormous expense of works for the protection of harbours and arsenals has limited such works to our most important Government dock-yards, while the mercantile ports and the coast generally remain unprotected on account of the expense. With a supply of these carriages and heavy ordnance, any harbour or part of the coast can be put in a state of defence in a short time by sinking gun-pits in suitable situations, and these gun-pits would be more formidable to shipping than batteries, which are easier seen and at the same time more vulnerable. On an open coast, or at the entrance of harbours, circular

pits might be made in any position even, to the water's edge; in the latter case protected below by iron sheeting. In either case, the soil being removed or spread, such guns would be completely masked, and would give no indication of their position except at the moment of firing. For harbour defence in smooth water, guns might be mounted on this carriage on rafts or barges, only showing a few inches above the water, and exposing very little to an enemy's fire. In such cases, if the circular racer was dispensed with, the gun would fire in line of the keel.

In the colonies, such a system of defence as is here indicated, might prove of important value. It will be observed that a modification of the same principle might in some circumstances be adapted to armour-plated vessels.

I shall now take the liberty of reading two detailed reports of the performance of a model made on one of my plans:—

The first is from Colonel Dickson, C.B., R.A., V.C., who, at the date of his report, commanded the Royal Artillery in North Britain, and before whom and four artillery officers of the station, the experiments were made. The second is from Colonel Alaric Robertson, the able designer of the Indus Tunnel.

"Royal Artillery Office,
"Leith Fort, 20th February, 1865.

"After a careful perusal of your paper, describing an improved gun-carriage invented by you, and also examining your model of the same, I am of opinion that your invention is one of very great merit, and deserves to receive the fair consideration of the Secretary of State for War; I would, therefore, recommend it most strongly to his favourable notice.

I have also seen the gun (an iron model of a 68 pounder, weight 1 cwt.) fired with a charge of one-quarter the weight of an elongated shot, weighing proportionately one-half more than the shot of the gun of which it is a model; and the result appeared to me very satisfactory, as regards the object sought by the invention.

I am glad to think that the idea submitted by you to Lieutenant-General Sir Richard Dacres, R.A., and myself in Dublin, in 1858, and which met with the General's approval, has been so well worked out.

(Signed) "C. DICKSON,
"Colonel, Royal Artillery,

"Captain A. Moncrieff."

Report of Colonel Robertson on Moncrieff's Protected Barbette System.

I believe that the system of defence by gun-pits, and elevating carriages, invented by Captain Moncrieff, and which is, to some extent, described in his paper on the subject, is one of great importance, and meets an acknowledged want at the present time.

I have watched the progress of a working model of his carriage for a 95-cwt. gun on ½ scale. I have also seen the gun fired with charges ranging from ½ oz. of powder only, up to a 6 oz. elongated bolt with 1¼ oz. of powder, the diameter of the bore being 1-$\frac{5}{16}$ inches, and the weight of suitable solid iron shot 4¼ oz. nearly. In every case the performance of the carriage has been most satisfactory; with the heavy charge the recoil was easy and smooth, right down to the check buffer, and without the least jar.

I was much struck with the ingenious manner in which the great difficulty of dealing with a balance weight for heavy ordnance was overcome. In fact the whole

machine has the characteristic of all great mechanical inventions, and one especially necessary to those connected with artillery, namely, extreme simplicity.

The conclusion which forces itself on me is, that it must work on a large scale as well as in the model, as, even were the conditions to change with the larger gun, there is so much power of adjustment to meet any new conditions that would arise in experiments on a larger scale, that I believe the problem of elevating guns by counterweight is now solved.

"(Signed) A. ROBERTSON, Colonel.
Retired List Indian Staff Corps, late Superintendent Engineer Indus Tunnel Works, and 1st Circle in the Punjaub.

I shall here mention, in passing, two of the principal difficulties which I had to contend with in dealing with this subject and to overcome which I had to reject many plans for elevating guns by counterweight, since I first conceived the idea of using it in 1855, while watching the effects of the bombardment of June from our good earthen batteries in the Crimea.

The first of these difficulties was to hit on a plan by which heavy counterweights could be employed without subjecting the machinery to the shock that fell on it as long as the fulcrum between the power of the recoil and the resistance of the counterweights remained stationary, in, or about that machinery.

The second difficulty was that of divesting the gun carriage of all complications and intricacies, believing that in an ordinary weapon of war, simplicity in its parts, is the highest merit.

With what success I have overcome these difficulties in the plan now submitted, I leave this meeting to decide.

The four objections to my system, communicated to me by the Director of Ordnance, on which the Ordnance Select Committee refused to give my carriage a trial, were as follows:—

1st. "That it is too complicated in its arrangements to be serviceable.

2nd. "That the protection which it would afford would, at best, be very imperfect.

3rd. "That its great weight, equal to that of the present gun and carriage taken together, would necessitate the provision of special platforms, pivots, and racers.

4th "That, in the opinion of the Select Committee, the advantages which you anticipate from the adoption of a gun-carriage, of the kind proposed, are much over-rated and are incommensurate with the expense which would attend its introduction, and under these circumstances Earl de Grey must decline to entertain this subject further."

The last sentence shuts my mouth as far as the Select Committee is concerned; but I suppose there will be no harm in my answering the four objections here. I shall, therefore, take them up one by one.

As to the first objection, viz.:—"That it is too complicated in its arrangements to be serviceable." I feel this to be a very difficult objection to answer, as it is merely a matter of opinion, and the opinion of the Ordnance Select Committee ought to be a very valuable one. I can only say that, to obtain the conditions sought for, some appliance must be used, and it must depend on whether

these conditions are a sufficient improvement to justify the appliances. I am still persuaded that it will be admitted on closer examination that my plan is a very simple one.

The second objection, viz.:—"That the protection which it would afford would, at best, be very imperfect," is more easily met, as the amount of that protection is very easily ascertained. I shall take for instance, the case of my carriage being used in an ordinary embrasure, or casemate battery; the difference, in that case, between an ordinary carriage and mine is simply that of the gun being *always* exposed to a shot through the embrasure in the former, and of being only exposed for the few seconds required to point and fire, in the latter, with the additional advantage of having the gun detachment covered from musketry, without the necessity of using mantlets.

In the case of a barbette battery, my carriage, I think it will be allowed, has a still greater advantage over the ordinary one now in use. And, considering it is possible to lower the gun to any desired depth by regulating the size of the elevators, I do not think I went too far in saying that, except at the moment of taking aim, my carriage is unexposed to any except vertical fire. In the case of the carriage being mounted in gun-pits on the natural surface of the ground, I conceive it would need a rather vigorous direct fire to level the battery!

The third objection is "That its great weight, equal to that of the present gun and carriage taken together, would necessitate the provision of special platforms, pivots, and racers." This objection could scarcely be urged if the advantages are anything approaching to what is claimed, but, as these advantages may not all be allowed, I beg to state, that the weight is no serious objection in a garrison gun; the weight of the walls of a fort are not objected to; and as the counter-weight used with my carriage may consist of pig-iron, spare shot, &c., held in an iron basket, it can be transported on the same conditions as any other small material.

With regard to the necessity of having new pivots, platforms, and racers, I must here respectfully dissent from the opinion of the Ordnance Select Committee. I shall take the liberty of making a comparison, and leave it to answer this objection. If a cannon were mounted on a common railway truck and fired from it with impunity at right angles to the line of rails, would it be necessary to strengthen these rails if you doubled the weight on the truck and fired the gun in the same line as the rails?

The experiments with my model were made in winter, and when fired, it was placed on a large flat door, which happened at the time to be covered with ice, on which the model rested like a sledge; it did not escape the notice of the officers who witnessed the trials, that although very large charges were used, the model remained stationary on the board, and it was the most satisfactory evidence that my theory in regard to the recoil would coincide with practice.

I now come to the fourth and last objection, namely: "That in the "opinion of the Select Committee the advantages which you anticipate "from the adoption of a gun-carriage of the kind proposed are much

"overrated, and are incommensurate with the expense which would "attend its introduction." In reference to this objection I shall take the liberty of quoting from the professional papers of the corps of Royal Engineers; in a paper read by Lieutenant-Colonel Gallwey, R.E. (on 7th March, 1865, page 45), and to which I would request particular attention, as the whole argument applies in the most pointed manner to the subject we have before us; referring to lateral range in comparing a two-gun turret with guns behind embrasure shields:—

"We may ask, then, admitting the above comparison, if two guns "in a cupola can cover as much ground as six mounted behind shields, "what would be the number of guns in ordinary earthern embrasures "that would produce an equal effect, looking at the superiority of pro- "tection as well as range controlled? The answer might be: If it be "admitted that one gun behind a shield is worth three behind ordinary "embrasures (as it certainly would be), then the two in the cupola "would be worth eighteen in earthern embrasures, and this estimate "is not extravagant if it be closely examined:—

"1st. The cupola gives, supposing it to be placed on the salient of "a polygonal fortress, a lateral range of at least 180°. 2nd. Except "while the guns are being pointed and fired, the embrasures (by turn- "ing the cupola a quarter of a circle at the most) are secure from the "fire of both artillery and musketry. 3rd. When in the above posi- "tion the cupola, guns, and detachment are perfectly safe. But "instead of accepting the proportional value of 2 : 18 let us take it "as 2 : 12 and see what is gained. A cupola intended for the defence "of an inland fortress need not be nearly so strong as one required in "a maritime fort or battery. A cupola for this service may be built "on the system of 'La Gloire' in preference to that of the 'Warrior.' "The principal of the former consists in screwing small plates, say "5 feet by 3 feet, to a wooden backing and an inner skin of iron, all "bolted together, the inconvenience of the system being the breaking "of the bolts and nuts on the inside. Small iron plates of the above "dimensions, and four inches thick, screwed to two thicknesses of "nine-inch oak, would probably do for a target which would be im- "penetrable by any gun that could ordinarily be brought into the "trenches.

"The cost of the 'Royal Sovereign' cupolas, which hold two "12-ton guns, is stated by Captain Steward to have been £4,500, "including very expensive brass fittings. The cost of a cupola for "two 7-inch guns, as above proposed, would not exceed £2,000. Then "as to comparative cost at the rate of two to twelve:—

"Cupola	£2,000
"Two 7-inch guns and carriage	900
	£2,900
"Twelve 7-inch guns and carriages	£5,400
"Twelve traversing platforms, curbs, racers, &c..	840
	£6,240

"In addition to the above great saving only two gun detachments "are required in lieu of twelve. Looking at home I cannot help "thinking that we should save a vast expenditure in guns, and a great "deal of money in other ways, if our new land defences were pro-"vided with cupolas. There is no other country in the world whose "interest in economising men is so great as that of England. Much "has been said and written antagonistic to the policy which dictated "the necessity of fortifying our dockyards on the score that all our "forces would be absorbed in their defence, and that in consequence "we should have no army left to fight that battle which must be "gained in order to save the capital. Without at all sharing such "views, I think the adoption of the cupola system of defence would "be the means of obtaining a minimum garrison of security for those "places, and set free a considerable mass of men for the army in the "field."

Having read the above quotation, allow me to analyse the advantages which give the cupola gun so much greater value than others. The whole of these advantages may be ranged under two heads, viz., first, free lateral range; and second, protection to the gun and the detachment. Now, if my carriage works at all, I beg to state that it enjoys the first of these advantages to the full, equally with the cupola; and in another part of this paper I went some way in proving that it had a good deal of the protection referred to in the second. But then the Ordnance Select Committee are of opinion that the advantages which I anticipate are incommensurate with the expense which would attend the introduction of my carriage.

The advantages I have now discussed. The expense of making an experimental carriage would be something under £100 and the use of a few tons of pig iron.

Referring again to Colonel Gallwey's paper, I beg to point out that his reduced estimate for a light cupola of two 7-in. guns was £2,000. And this, by his showing, would not be of sufficient strength for coast batteries, which would require a stronger cupola, costing upwards of £4,000. Bearing in mind, however, all the advantages of the cupola system over the present one, which Colonel Gallwey so clearly illustrates, I would state that my system can be adopted for either coast or inland batteries; that I have no cupola to be broken by enemy's shot; that there are no nuts to become loose; that my carriage will not cost much more than those of a dwarf traversing platform battery; and that the free lateral range of my guns is only limited by the position in which they are placed.

To sum up what has been stated, I submit that this carriage, by a simple application of counterweight with a moving fulcrum, lowers the gun out of fire, and enables a small gun detachment to load with heavy projectiles at a convenient angle for running home the charge. That the gun of its own accord rises into the firing position, the energy of the recoil being stored to make it to do so. That it may be laid with a reflecting sight without exposing any of the gunners. That from the fulcrum between the gun and counterweight being a moveable one, the jar and shock caused by firing and transferred (in the case of the

ordinary carriage) by friction to the platform, is in my carriage got rid of, and that consequently the materials of which the carriage and platform are composed will last longer. That free lateral range is obtained and all its concomitant advantages, such as enabling a few guns to do the work of many, and a few men to supply the place of many men, while these few are much less exposed than they would be in any system except that of cupolas. That the expense of my carriage, notwithstanding its many advantages, is not nearly so great as that of the cupola, in fact is not much greater than the one now used. That it is only exposed to direct fire during the very few moments required to point and fire, and on firing, descends of its own accord out of harm's way, and therefore enjoys an advantage over all other barbette guns, as well as those at present used in embrasures and casemates.

Having re-stated this, allow me to express a strong conviction (which I hope you will excuse me for mentioning) that such a carriage as I have described, must one day be adopted. My reason for thinking so is founded on the fact that it effects an enormous economy of *labour*, *material*, and *life*, and that the embrasure system has defects, which were inconvenient even with the old ordnance, but which, with the enormous penetration of modern ordnance, I believe will be found wanting under the test of actual war, except where armour coating is resorted to. I may here mention that I was told by an officer (Colonel Rhett, formerly U.S. Artillery) who was Director of Ordnance at Richmond during the late American war, that (even against the comparatively light rifled ordnance employed by the Federals in their inland operations) the Confederates had to abandon entirely the use of embrasures, and mount their guns *en barbette*, the actual security of the gun detachment in the latter case while not loading, making up for their partial security in the former.

I am now most anxious that the Government should re-consider their decision regarding my invention, and that they should put it in my power to shew them, that what my model has done, and which is certified by able and experienced officers, can also be done with guns of full size. If this Institution should be the means of procuring for me a fair trial, I shall be grateful to it for the recognition of any merits that my invention may be found to possess.

Captain HEATHORN, R.A.: Perhaps Captain Moncrieff will be kind enough to tell us exactly to what amount of exposure the individual employed to elevate and depress the gun to get the aim, would be exposed. When you have elevated your gun from the bottom of your gun-pit, you are to lay it on some object. The man who lays the gun stands up under the brink of the parapet or under the crest of the gun pit, and looks on the reflecting sight by which he is enabled to point the gun. What power is used to traverse the gun on its trunnions sufficient to get the gun on its elevation, and where is the man placed who does that? I should like again to ask if you wish to apply your gun-carriage, not only to siege guns, which would be perhaps 40-pounders, or seven-inch guns at the most, but to guns on salients, which would be our strong points of defence in coast batteries, and harbour defences generally, what weights do you calculate upon being able to bring into action to raise such masses as 12-ton guns on your principle? Again, in the case of guns being able to fire over one another, when your gun-pits are in direct line, one in rear of the other,

would not the gun-pits, of necessity, in positions of elevation one above another, be very much exposed firstly to your own direct fire, and much more so to direct and vertical mixed fire of the enemy? Again, although your gun would not be very often exposed to direct fire, should you get it attacked in flank when the gun was up, have you any means at all of being able sufficiently to repair the gun gear to be able to go on again, or will it be entirely destroyed?

Commander COLOMB, R.N.: Although not a military man, I am interested in these questions because they refer to points which are at any rate partly naval. I think it is worth drawing attention to the fact, that at the last lecture we heard here, on "the present state of the question of fortification," the lecturer at the close of his paper drew especial attention to the necessity for some arrangement such as we have had described to us to-night. As I understood him, he said that embrasures were not satisfactory; the system of firing *en barbette* was not satisfactory, owing to the exposure to which the men were subjected in loading and pointing the gun; that the cupola system had not been determined upon; and that we wanted something of this very kind. I do not suppose that there was any collusion, but it strikes me as rather a remarkable coincidence, that we should have had our attention drawn to this point to-night. The plan before us has, I fancy, at least the merit of very great novelty. The idea of raising guns from behind parapets from the loading position, to above the defence in the firing position, has been brought before this Institution in a paper read by Captain Inglefield, R.N., who proposed to raise his gun for ship use also, by hydraulic pressure. I think there can be no question whatever of the superior value of a counterbalancing principle, supposing you can get it to act. I listened with great attention to the lecturer's remarks upon his experiment, because the experiment is really the whole gist of the matter. Without experiment it is almost impossible to express any opinion on such subjects. I was very much struck with his statement relative to the platform upon which his gun was worked,—and I would like to ask whether that is actually the model that was used. (Captain MONCRIEFF: It is.) That gun on its frame, being fired when upon a sheet of ice, did not in any way disturb the frame from its place. I think that it is a very remarkable adjunct of the experiment, because it seems to me to prove most clearly, so far as it went, that the strain was taken off the object upon which the frame was bearing; and, therefore, it would have been taken off the racers almost entirely. Of course I think the lecturer was perfectly right in his remark, that increasing the weight on the platform would certainly decrease the friction or strain upon the racer; there can be no question about that whatever. As regards a remark that the last speaker made,—I did not quite catch what his argument was—he spoke of the case of a gun raised out of one gun-pit, and fired over another gun-pit—whether that would not expose them to direct fire?

Captain HEATHORN: I think Captain Moncrieff stated that gun-pits might be in rear of one another, or on a height—not *en échelon*—and might be able to fire one over another.

Captain MONCRIEFF: I stated that guns not on a height, but guns on a plane, on an emergency, might be fired one over another.

Captain COLOMB: What you meant, was that you might have your gun-pits behind one another upon a plane, if necessary, and that when the gun in the foremost gun-pit was down—(Captain MONCRIEFF: Or disabled)—that the gun behind it would fire over it without injury to the men in the pit. I cannot but help regretting that we have not had an experiment on a larger scale, to have given us some further facts. I have a great idea of facts upon a small scale, so far as they go, but the distance they go is only sufficient, as a rule, to encourage the inventor to go further, but it is not sufficient for the country to get, or for us to express a distinct and strong opinion upon the merits of an invention.

Captain HEATHORN: Before Captain Moncrieff answers our questions, I think we might be allowed to express our approbation of his great ingenuity in being able to bring any counterpoise as a means of checking recoil. It is the best application of counterpoise for checking recoil I have yet seen.

Captain WAKE, R.A.: In placing your gun, say, in such a position as in the ravelin of a fortification, what is the space occupied by one of your gun-pits?

Captain HEATHORN: About what passage do you pass through from the position of loading your gun, when retired into the gun-pit, to that position of elevation to which it is brought for pointing? Is it optional? Can you make your gun rise, and then fall to the bottom of your gun-pit at your discretion?

Captain WAKE: Suppose you think it necessary to elevate your gun from the *terreplein* of your gun-pit eight feet, or suppose it was necessary under other circumstances to raise it more or less, can you do so optionally?

The CHAIRMAN: Perhaps you will be kind enough to show the model in action. You can, I daresay, imitate the action of the recoil. It would tend to elucidate the subject.

Captain COLOMB: Do you think that an improved form shown in the drawing (Plate xxiv)?

Captain MONCRIEFF: I have three or four different forms. I may state now that I have only just come home from the East, and I have had very few days to prepare this paper and the diagrams for this meeting. But, had I had a little more time, I should have shown two or three more designs in section and in plan.

The CHAIRMAN: It is my pleasing duty to-night, as an Officer of the sister service, to compliment the lecturer on the extreme ability he has shown in dealing with this subject. He has, undoubtedly, by not very complicated machinery, produced an effect which we have all long ago thought was desirable. And although it may, perhaps, be fitly objected that the smallness of the model gives but little idea of what would be the effects with a larger sized gun; yet as no inventor could in such matters be called upon fairly to expend sufficient sums of money himself to demonstrate the value of the invention which he has made, to the public, so it is only fair, if sufficient cause be shown, if the promise of advantage gained is sufficiently great, that then a public trial should be given, as it has been given to much less promising inventions, requiring much larger sums of money. It is increasingly difficult for the unaided Officers of the services, to bring forward those things which they have elaborated painfully and with great trouble; it is not only difficult for them, but it becomes excessively discouraging, when, as in so many recent instances, they find that no sooner are those inventions which they have brought forward, acknowledged to be of public utility, than—I do not wish to say by whom—their inventions are adopted piecemeal, and they themselves are left without reward or acknowledgment. Although as a Naval Officer, I am not, perhaps, by any means the best person to judge of artillery inventions, particularly those which are applicable to fortresses, yet, as it often happens, that those who have to undergo an attack are the best judges of the efficiency of that attack, so I may mention that during the whole history of our Navy, it has been known that two forms of battery were most formidable to shipping, the one—which is the form that was known as the "Wasp Battery" in the Crimea—where the gun is placed high above the level of the sea, and is consequently not easily attackable by any fire from artillery having a limited elevation, as must always be the case in ships; the other where the battery is either on or near the sea level, known as *à fleur d'eau*. The shingle beach, which lines a very large proportion of all sea coasts, heaped up as it is by the action of the waves, offers a resistance provided by nature, which may favourably compare with the best cupola that was ever made. Guns mounted in gun-pits behind that shingle, and elevated by such means as those which have been submitted to us, would prove the most formidable, as well as the most easily established modes of defence that have ever been adopted. To establish a cupola battery, there is first necessary a very high degree of skill in making it; there is, secondly, necessary a very large expenditure in expensive machinery for training the guns, or, if the cupola be moveable, the cupola itself. There is one point to which the Lecturer adverted, in which I cannot quite follow him, that is, the value of a smaller number of guns in a cupola, as compared with a larger number behind embrasures. Now, although it may be perfectly true that embrasures will have to be abandoned as most insufficient means of protecting guns, yet, as long as the attack is conducted from a variety of points, and not from a single point, so long will the cupola be found inefficient to repel the attack, which can be conducted by a number of different guns. There will also always be the danger that more or less "your eggs are in one basket,"

and that the disabling of two guns is the disabling of the whole battery, whereas they form only a proportion of the larger number which may be employed on the other side. In that respect, therefore, I do not quite follow the Lecturer's opinion, but as I understood him afterwards to speak of gun-pits as compared with cupolas, in which case there is no limit to the number of gun-pits which may be employed, I conceive that the objection may be met fairly in that way. We have had recently a most excellent instance, of which I hope we shall see still further details, and which will prove very interesting, of the power of a well-conducted heavy artillery to reply to a severe attack by shipping. In the port of Callao, on the coast of Peru, there has been—to-day's paper gives the account—a successfully repelled attack. I must remark that, as regards the employment of heavy artillery in the attack, as well as in the defence, it has been abundantly proved that it is worse than absurd to attempt to reply with any number of small guns to one heavy gun; that, consequently, we must look forward to the use of heavier guns, though they may be in smaller numbers; and that the mechanical appliances of the age are not at all insufficient to meet the question, either of raising these guns into their places, or of bringing them up to their position, or again, of carrying them with ease, and fighting them with rapidity as broadside guns on board ship. The 68-pounder has only within the past few years taken its place as a siege-gun—as an acknowledged siege-gun. The 32-pounder has only since the mutiny in India taken its place as an acknowledged field-gun. The advance which we have made in that direction, will inevitably be followed up as we improve our machinery, by still further advances—one 300-pounder being more than equal to six 68-pounders in the field. The questions on my own behalf which I should like to be answered by the Lecturer would be, not as to the liability to destruction by enfilading fire, or by vertical fire, or by any other way, for this it must share in common, I conceive, with all other natures of artillery in action, but the points to which I have briefly adverted. It is true that the surface of gun-carriage in the plans before us is rather more, but the complication of the gun-carriage is not greater than those which are now adopted for all our heavy guns, and it seems to me that the whole of the appliances may be easily found within the resources of any garrison, or any park of artillery. I am quite certain that where expensive wrought iron and large quantities of machinery are employed, these will not be so easily repaired as where wood forms a large proportion of the material of the carriage. With reference to the raising of a gun if dismounted, I see that the machinery employed for the working of the gun may very easily and very properly be turned to account in the remounting of a gun, if dismounted. The absorption of the power given by the discharge of the gun in the recoil is probably one of the most important subjects to which attention could possibly be given. Hitherto it has not only been waste power, but worse than waste power, because it required the energy of a large number of men in order to restore the gun into its position before it could again be fired, independent of the loading. In the present case, that is entirely overcome, and I presume that, with the gun in good order, mounted on such a carriage, one-third of the number of men, to say the very least, might efficiently fight that gun, that could be now employed with any of our running in and out carriages. I think I have gathered the sense of this meeting—small as I am sorry it is, from the stress of weather—so far as to be able to say that the lecturer receives most deservedly our most cordial thanks. Whether or not he may be able to gain recognition from the Government, he will not fail to obtain recognition for his inventive talent, and the perfection to which he has brought his models, from an Institution composed as this is of men connected with the two professions.

Captain MONCRIEFF: I am very much obliged to the Chairman for his very handsome remarks regarding my invention. I hope that my anticipations will prove correct and justify them. I shall endeavour to answer the questions that have been put by gentlemen. I think the first was, how the exposure of the gunner who laid the gun, was to be provided for.

Captain HEATHORN: I referred to the man or the power that you employ to raise that gun on its trunnions, and get a sight: the man that lays the gun.

Captain MONCRIEFF: I propose that the reflecting sight should be screwed on to a double plane at the breach of the gun, so that in case of its being injured in action it could be replaced; or it might be fixed with three adjusting screws.

The CHAIRMAN: The question of Captain Heathorn was addressed more to the means of elevating and depressing than to the means of laying the gun by the sight. Perhaps Captain Moncrieff will take that into consideration. It is the mechanical means of elevating or depressing the gun that was referred to.

Captain MONCRIEFF: Pardon me, the gun can either be worked in the usual manner at the rear by No. 1, standing up as he does at present, or if laid by the reflector, No. 1 stands under cover of the parapet or pit, and by an iron rod with a handle, like a railway break, he works the elevating screw, while looking through the sight.

Captain HEATHORN: I only asked the question because I thought, seeing the lever there on the elevating screw, that the gunner would be unduly exposed.

Captain MONCRIEFF: The next question asked was with reference to the case of firing *en échelon*, which was to some extent answered by another speaker; but I shall refer to it. Suppose it was desirable to place a number of guns in a fort where space was important: in that case, if the guns were mounted in gun-pits, and an emergency should arise where it was desirable to open a strong fire for a short time in one direction, they could fire alternately over one another. When the gun in the front was down, the other gun could fire over the same ground; whereas if there had been one parapet behind another parapet that could not be done. Captain Heathorn also made a remark in regard to the gun being taken in flank. I think I am indebted to one of the other speakers for stating that every gun taken in flank must offer a larger space than if taken in front; and my gun, in common with all other guns, must be open to the same objection. But I would beg to remark that, whereas other guns are always exposed to flank fire, my gun is only exposed to it for a few seconds when firing. Therefore, even in that particular it enjoys an advantage over other artillery.

Captain HEATHORN: In our present system of fortification, I think between all our large guns we have a traverse. I do not raise this question as an objection; I only want to understand your scheme as best I can.

Captain MONCRIEFF: You cannot have a traverse where you have free lateral range.

Captain HEATHORN: In all the large forts they are building, there is a traverse between every gun.

Captain MONCRIEFF: In that case you have lateral protection but not lateral range. With regard to the remark about the coincidence of one lecturer pointing out a want, and another supplying it, I beg to say that I spent the winter in Nubia, Egypt, and Syria, far from newspapers, and did not know what was going on, but accept it as a happy coincidence that the same idea should have engaged one mind whilst another was engaged in developing it. With regard to the increased weight of the carriage, I should like to explain that that was a point objected to by the Select Committee, on the ground that I should require new racers, pivots, and so on, for my guns. Now, I think, with all deference to them, that they could not have closely examined into the matter, or they would have noticed that the increased weight, instead of being detrimental, is absolutely beneficial to the platform; and if they had also recollected that, with the present dwarf traversing platform gun, the strain is conveyed by friction right through the frame down to the platform, and is received at right angles to the racer, by placing another set of rails longitudinally or parallel to the recoil, I relieve the racers from strain. With regard to the observation that I had not conducted this experiment upon a large scale, I may honestly state that if I thought my doing so, would have mended matters, I should have gladly done so, but I know very well that had I spent more time and money upon a thing which I myself am thoroughly convinced will act upon a larger scale, I should probably have had to go through the same difficulties again to convince those who must be convinced before it can be adopted. It would be better if these experiments were conducted at Woolwich, I being present; and I hope the Select Committee would not do me the injustice to conduct the experiments upon a slightly altered plan without my being present. I hope they will not do that. I think I have carried the subject far enough in the mean time, and that I should leave those whose duty it is to select the wheat from the chaff in all inventions that are brought before them, to acknowledge the merits of mine. I think another gentleman asked

me what space was occupied by one of my gun-pits. Roughly speaking, the diameter is something less than twice the length of the gun. This is an exact model made to one-sixth scale of an ordinary 95-cwt. gun, and the pit, shewn in the diagram, is 20 feet in diameter. The depth is, I think, between nine and ten feet. I may remark that the whole extent of the depression is not shewn by this drawing; for instance, with these elevators, by altering the arrangement, you could bring this axle lower down—you could get it several feet lower down if you wished it. I should like to point out to this meeting that in case—which I do not anticipate will be the fact—of a guide being required to steady the wheels (Plate xxiv), a rail might be employed to guide the axle, and instead of having this arrangement as a check, you might have a small tongue on the rail as a check. It was also asked, is it optional to raise my gun to any height?

Captain HEATHORN: I meant to say, would you have much more difficulty in raising it ten feet than in raising it six feet? I can see now that it would only necessitate a working arrangement of a little greater length.

Captain MONCRIEFF: You will observe from the drawing, that whatever the position of the gun may be, the centre of gravity remains about the same height, and therefore the whole is in equilibrium, only having a slight preponderance one way or another, which the gunners will have to observe. If you want it a greater height, you have the wheel a little higher, or else bring that axle down a little lower. In fact, the amount of power of adjustment is so great that you can do anything you like with this system. I was very glad to hear from the Chairman his remarks with regard to the use of the sea beach in connection with warding off the attacks of shipping, because I had arrived at the same conclusion, not from experience, but from the careful application of a little thought, and, if I may be allowed to say so, a little common sense. I conceive that if that advantage can be connected with any plan, it will be the plan of my gun-pits. For instance, on spits of land or sand, where they could be down near the water's edge, and where they would not be observed by ships or by anything on the water until the guns were raised in order to deliver their fire. And from the free lateral range which such a plan possesses, guns might be thus sunk in spits at the entrance of a harbour, and they would be extremely useful and extremely formidable in the defence of that harbour. With regard to some remarks, not quite understood, about the small number of guns in a cupola, I must state those were not remarks of my own; they were quoted from the paper of Colonel Gallwey, of the Royal Engineers. But I must say I agree with what he says regarding the power of a small number of guns in a cupola, because in a cupola of two guns, for instance, they possess great security from an enemy's shot—the same amount of security which would make them equal to five or six times the number of guns mounted in embrasures. Therefore, on that account, and on account of their lateral range they would have more power.

The CHAIRMAN: There is the question of simultaneous attack from different points.

Captain MONCRIEFF: In case of a simultaneous attack from different points, of course a greater number of guns would be required. I am glad you have given me an opportunity of answering the question about heavy guns, because I think if this system is worth anything, it is best adapted for heavy guns. You have already noticed that the machinery which I use is very simple; it is best to speak of it as two wheels, because those that you see in the model are merely segments (with slight alterations), of two wheels. I propose two wheels, and tires round them, in which the great tensile strength of malleable iron is used. A wheel is the most perfect form of lever you can adopt, therefore there can be no difficulty whatever in suiting these wheels to any weights that may be put upon them; and, as the counterweight balances the gun, it leaves the men who work that gun with merely the difference to overcome, which may be as small in the case of a very large gun as in the case of a very small gun. I myself can see no reason whatever why, with my system, the largest guns that are mounted at the present time might not be worked with two or three men. Suppose the whole of a gun detachment were killed down to two men, those two men would be enough to load and to deliver the fire from the heaviest gun ever turned out of a British manufactory.

The CHAIRMAN: Provided you had the machinery.

Captain MONCRIEFF: Provided we had machinery to meet an emergency of that kind. Even with common purchase and tackling you could do it. With regard to the remark that the surface of the gun-carriage is rather larger than in the ordinary gun, I may inform you that the outside line of that gun-carriage corresponds with the gun-carriage now in use, there is only a little bit extra, which could be shortened. The depth is the same as that of the present carriage (Plate XXIV).

The CHAIRMAN: That does not comprise the segment of the wheel; that surface of which you speak.

Captain MONCRIEFF: The segment of the wheel may always be below; and I think in many cases it will be desirable to have the carriage a good deal higher, because in that case it would keep the wheel and all the machinery much safer; and any shot coming into the battery by chance would only injure the carriage, so that you would only have to fix down the wheel to this place, mount another carriage on the wheel, and you would be ready for action again without a gun at all, which would be a great advantage in the day-time. With regard to the absorption of nearly all the force of the recoil in the counterweight, I think I have already sufficiently referred to that. I hope the meeting understands the principle upon which that is carried out. I believe that I have now answered all the questions that have been put to me.

Captain WAKE: I should like to ask one more question—what is the total weight of your gun-carriage on the platform, taking the gun-carriage and that bow- or wheel-shaped arrangement for the counterweight, as compared with the gun?

Captain MONCRIEFF: In this drawing I take it for granted that the counterweight is the same as the weight of the gun; but if it were desirable to make the counterweight less or greater, that could be done by altering the curves of the elevators, or by raising the rear or the front of the platform.

Captain WAKE: I do not quite understand you. I want to know the total weight. Suppose you were to carry that arrangement in a siege train, I want to know the total weight of your carriage and of the arrangement you make with the counterweight, as compared with the gun.

Captain MONCRIEFF: Suppose this arrangement were required for a siege train, the extra weight required would be another axle, a platform and rails, an iron basket for stones, and a limber; but you must deduct the weight of the corresponding arrangement now used with siege guns. Probably there may be increased weight here and there, but otherwise it is much the same as in any other platform gun; only I think it will be found in practice that it can be made lighter than my drawing represents it.

The CHAIRMAN: I may just say, with reference to the very great value of this question, that at this moment, as I see by the papers, we are again about to employ brick and mortar in building foundations for the coming forts (we hope that above ground they won't be brick and mortar, since that has been shown to be utterly inefficacious to resist modern shot); enormous foundations for forts on sea beaches, which when built, would probably be less effective and more expensive than a defensive armament carried out on this principle. There is, however, this difficulty, which has occurred to me with regard to siege guns were this plan adopted, viz., that where the sap has been carried up to a certain point, and it is desirable to make a battery, you must necessarily have a place where there is no rock, and where there is a certain amount of drainage. These seem to be the two objections, and as every system has objections, and as these objections equally exist in the ordinary form of battery, so I do not think they will be fatal to the adoption of this principle bye-and-bye. I am sure you will allow me to return our thanks to Captain Moncrieff for the very able and lucid paper he has read this evening.

LECTURE.

Friday, 15th June, 1866.

CAPTAIN E. GARDINER FISHBOURNE, R.N., C.B., Vice-President, in the Chair.

MODERN CARRIAGES FOR HEAVY NAVAL ORDNANCE.

By Commander R. A. E. SCOTT, R.N.*

I APPROACH the subject of the afternoon's lecture with some diffidence. I am not now about to advocate a proposal which has yet to be tried, but I have principally to describe a success which has been already achieved. The necessary consequence of this is, that I shall appear to some to be sounding my own trumpet somewhat loudly; and I must therefore endeavour, as far as possible, to let the facts which I shall lay before you speak for themselves. Still, I cannot forego the satisfaction of pointing out the opportunities which this Institution has afforded me of developing ideas which have since borne good fruit.

The importance of having such an arena for discussion as the theatre of the Royal United Service Institution, cannot be overrated, and I shall not be blamed by the lovers of this Institution if I demonstrate clearly that some of the first steps towards the realisation of my projects for working heavy guns on a broadside, were taken in this room, and that in this room also both sides of the question were fairly and freely discussed.

In May, 1862, in the discussion which ensued on Captain Fishbourne's lecture on the best gun for naval warfare, Sir W. Armstrong stated—"As regards present ships, naval men seem to be agreed that "it is not possible to carry broadside guns much heavier than the "present 68-pr., or, at the very most, that six tons must be the "limit."

In January, 1863, Mr. Barras gave here a lecture on the stability of ships in a seaway, and at that lecture I exhibited on the walls designs for a frigate and corvette, which were to be armed with 20-ton guns on the broadside, and the designs were accompanied by a table shewing the immense superiority of a few heavy guns over a number of small ones.

These diagrams and this table were again brought to your notice in March, 1863, on the occasion of Captain Arbuckle's lecture on iron forts and ships, at that officer's request, and the meeting wished me to explain them.

They are now again placed before you, that you may the more

* Now Captain Scott, R.N.—ED.

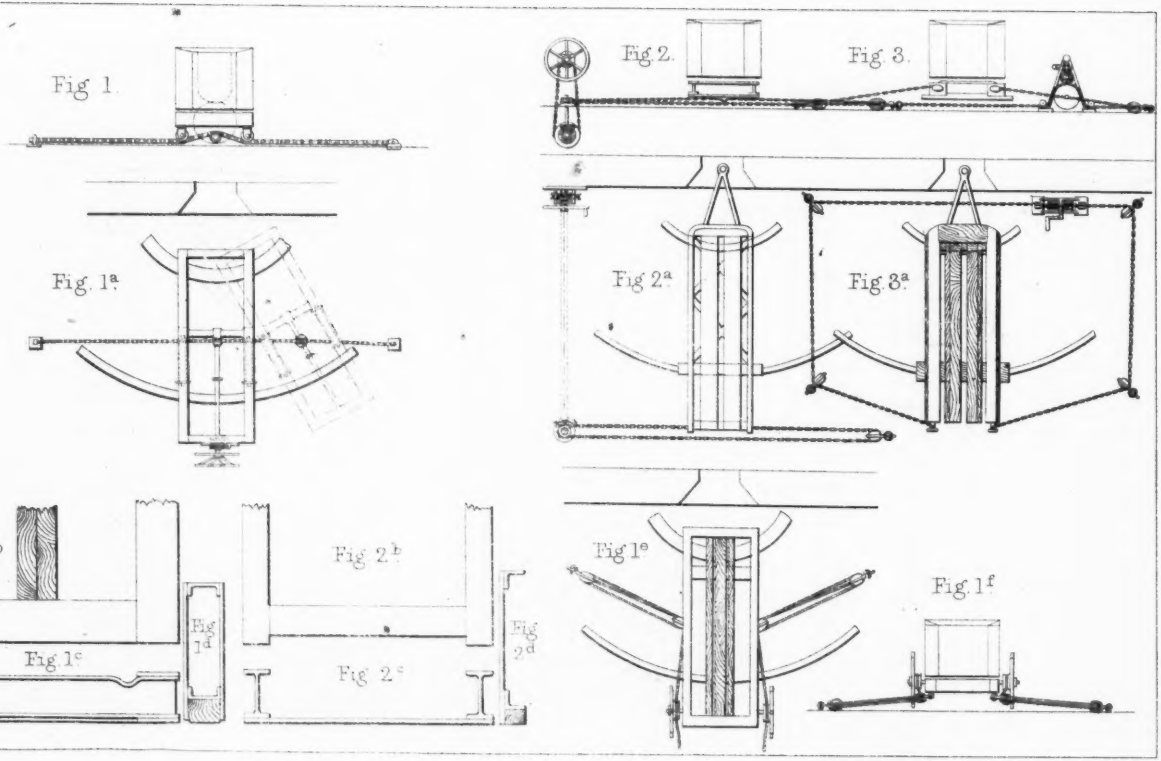
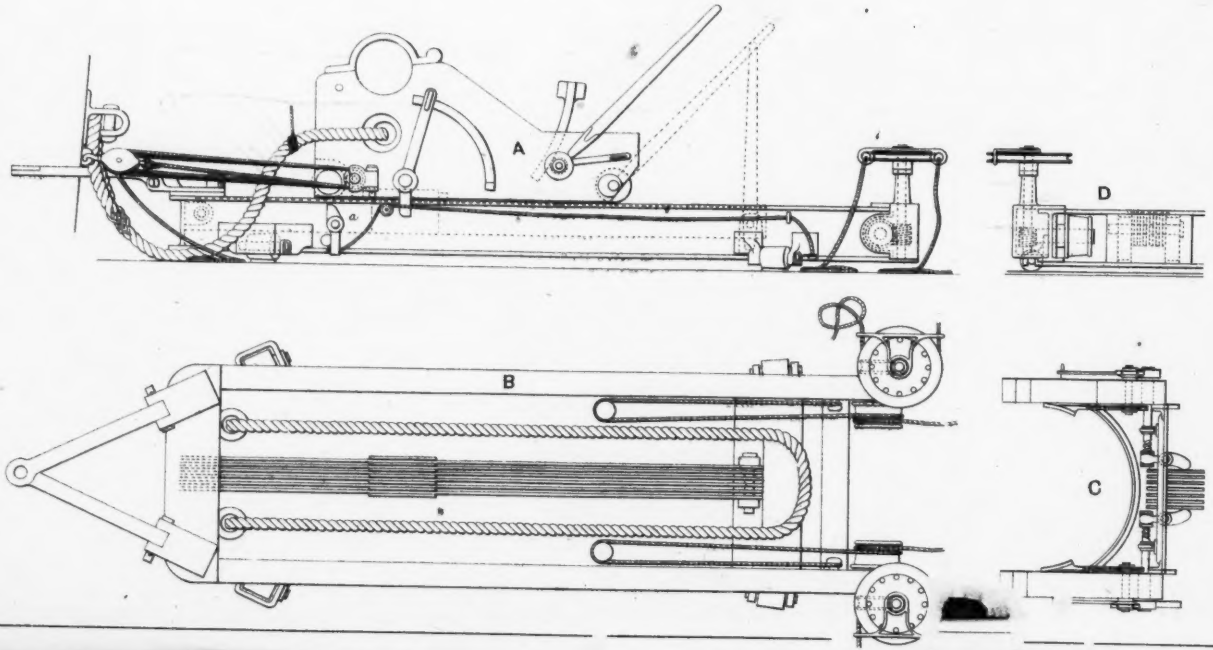


Fig 1.
Fig 1a.
Fig 1b
Fig 1c
Fig 1d
Fig 2.
Fig 3.
Fig 2a
Fig 3a
Fig 2b
Fig 2c
Fig 2d
Fig 1e
Fig 1f

J. Jobbins

BELLEROPHON.

Armstrong's Carriage and Slide.



J. Johbins

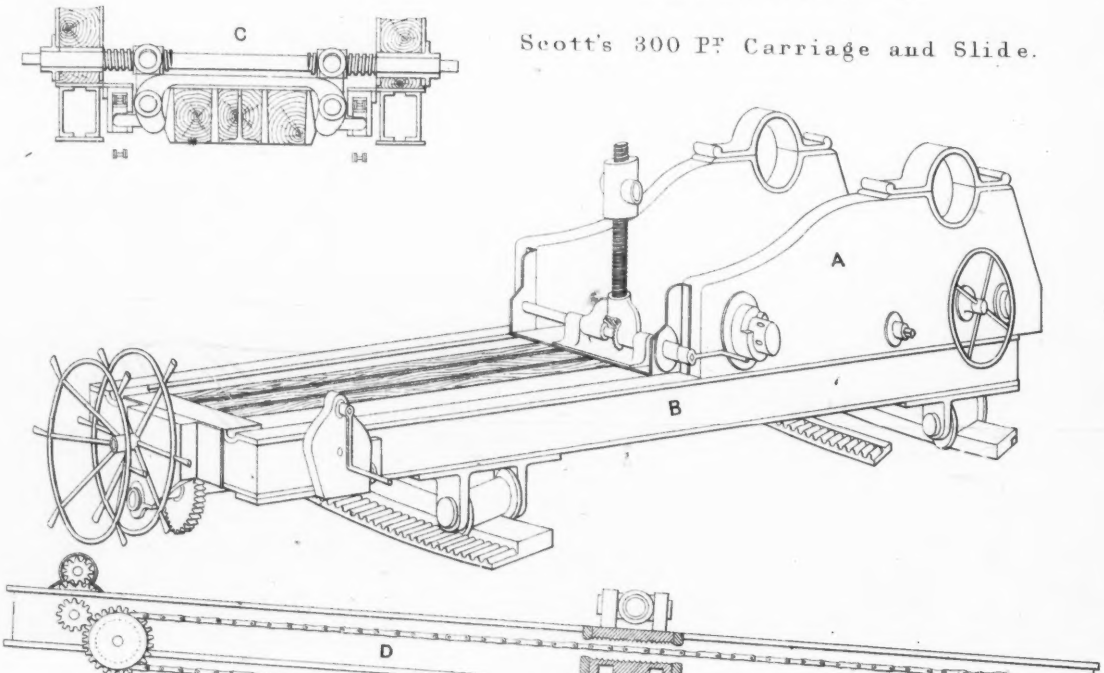
VOL. I.º

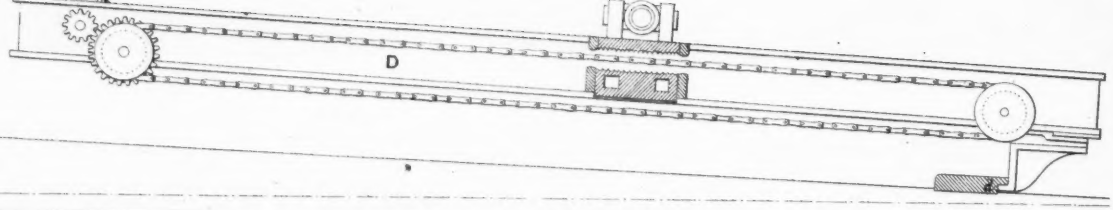
Pl. XXVIII.

Fig. 1.

BELLEROPHON.

Scott's 300 Pr Carriage and Slide.

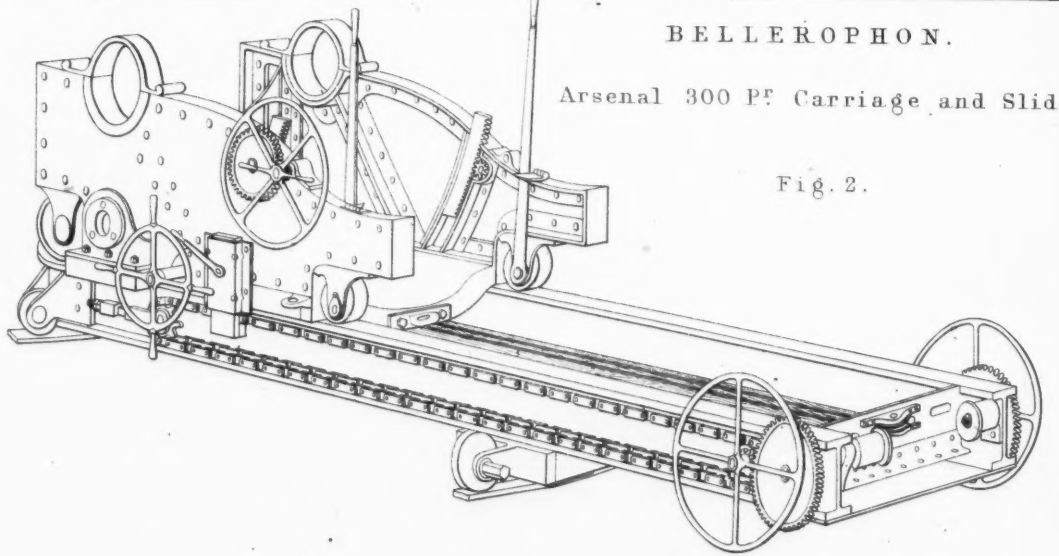




BELLEROPHON.

Arsenal 300 Pr Carriage and Slide.

Fig. 2.



J. Johns.

Pl. XXVII.

COMPRE

Fig. 1
OLD PATTERN.

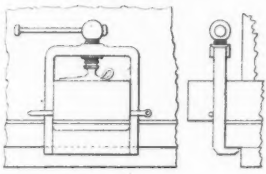


Fig. 4.
HOLDING DOWN
MINOTAUR.

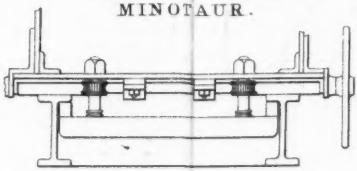
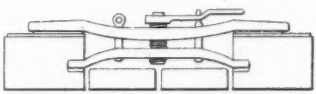
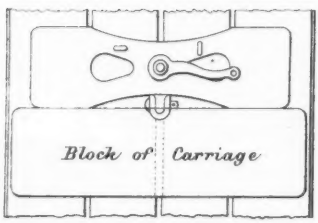


Fig. 2.
FERGUSON.





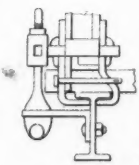


Fig. 5.
SELF ACTING
ECCENTRIC
MINOTAUR. R.C.D.

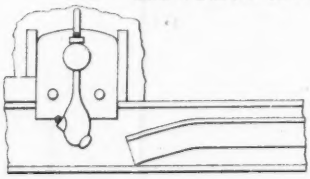


Fig. 3.
PLATE. R.C.D.

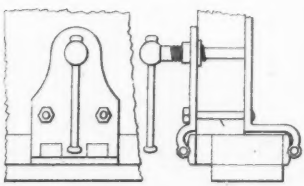
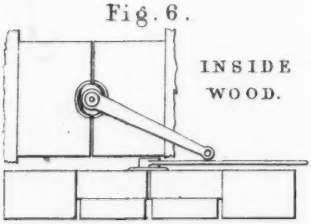


Fig. 6.
INSIDE
WOOD.



PRESSORS.

Fig. 7.

SCOTT'S MINOTAUR AND BELLEROPHON.

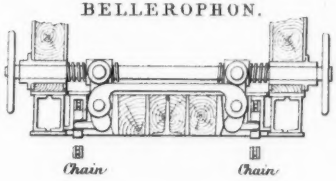


Fig. 8.

ARMSTRONG BELLEROPHON.

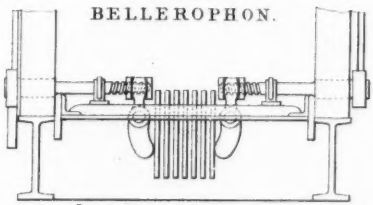


Fig. 9.

R. C. D. BELLEROPHON.

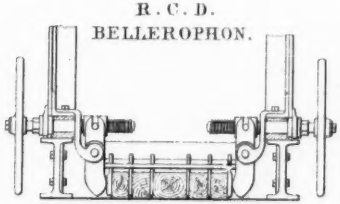


Fig. 10.

ERICSSON BROADSIDE.

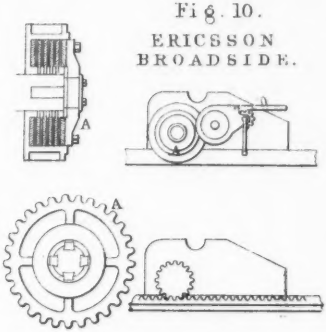


Fig. 11.

ERICSSON TURRET.

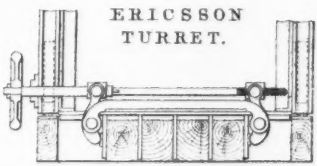
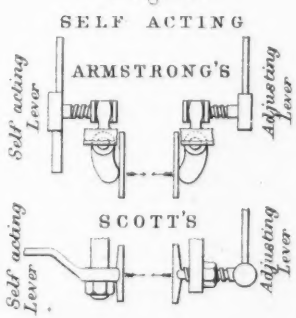


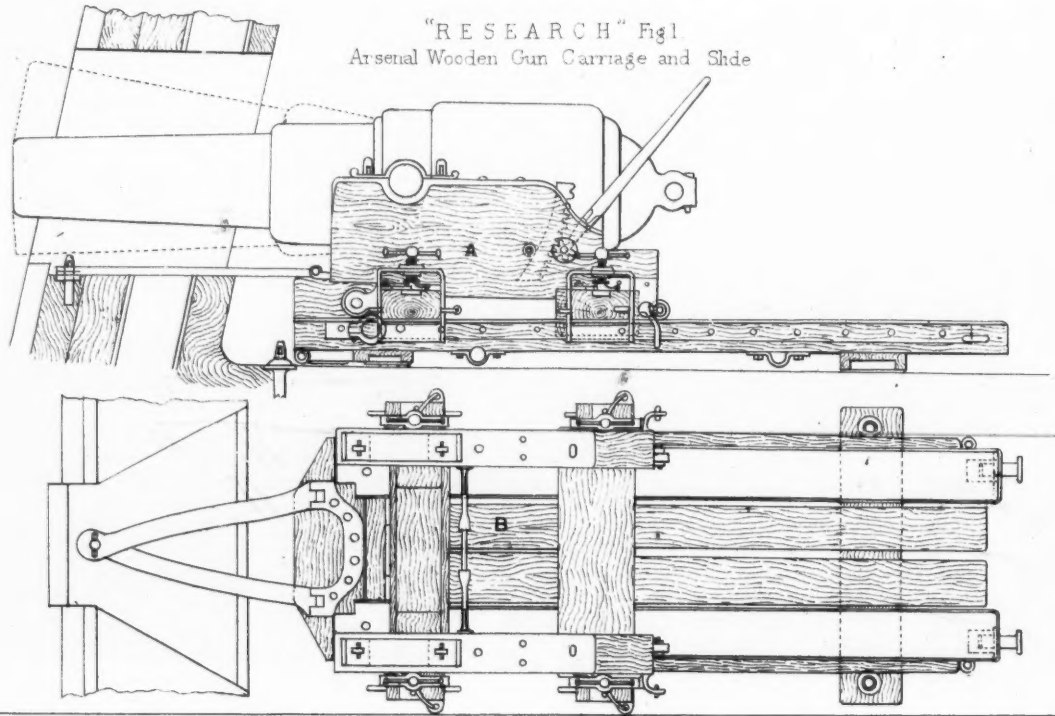
Fig. 12.

SELF ACTING



J. Jobbins

"RESEARCH" Fig 1
Arsenal Wooden Gun Carriage and Slide



Section through Iron Gun Carriage and Slide
Shewing 2d Compressor

"R E S E A R C H" Fig 2
Iron Gun Carriage and Slide 100 Pr Mounted

J. Jobbins

readily follow the course which events have taken as respects these proposals.

Comparative Power and Cost of Ordnance of different Calibres.

No.	Guns.	Weight. Guns.	Weight. Powder.	Weight. Shot.	Cost. Powder and Shot.	No. of Men.		No.	Gun.	Weight. Guns.	Weight. Powder.	Weight. Shot.	Cost. Powder and Shot.	No. of Men.
		Tons.	lbs.	lbs.	£ s.					Tons.	lbs.	lbs.	£ s.	
5	32-prs.	14½	50	160	2 1	65	=	1	68-pr.	4¾	16	681	40 14	17
10	68-prs.	47½	160	680	7 0	170	=	1	150-pr.	12	40	150	1 13	*16
7	150-prs.	84	280†	1050	11 10	112	=	1	330-pr.	26	80	330	3 8	*16
350	68-prs.	1662½	5600	23800	245 0	5950	=	5	330-pr.	130	400	1650	17 0	*80
20	68-prs.	95	320	1360	14 0	340	=	"Warrior's" Broadside.						

17¼ "Warrior's" Broadsides = Broadside of 5 Horsfall Guns.

* Number of men to work these guns in the manner proposed by Commander Scott in 1862.
† A thousand balls of 1 lb. weight each would produce no effect upon an iron-clad.

In February of the following year, viz., 1864, Mr. Cunningham commenced his lecture before you with this question—"Can we continue to

work our heavy guns by manual power?" and he decides the question in the negative. He thinks that "arms of flesh and bone must give way to the iron arms and sinews of the mighty steam-engine," and that though 12-ton guns may be worked by 21 men on a level battery deck, he doubts whether half as many again would be able to control such ponderous guns *at sea*. "One word," he adds, "more on this point:" "It has often been remarked to me by officers, that they always "dreaded casting loose their 68-prs. at sea, and were always delighted "when the guns were again secured. If, then, this anxiety existed "in regard to guns of between four or five tons in weight, how great "must it be, or rather will be, when dealing with guns three times "heavier, with probably all the embarrassing accompaniments of wet, "slippery decks." (See Journal Royal United Service Institution, vol. viii, page 70.)

In May, 1865, the Turret Committee sat, and Captain Preedy, in answer to Captain Kennedy's question—Can you imagine any possible way of fighting a 12-ton gun except in a turret? replied "No."

Captain Hornby stated before the same Committee that Captain Willes, having cast a 6¼-ton gun adrift in a seaway (that is to say, having removed the lashings, ready for working), the gun was unmanageable, and the men were afraid to go near it. The slide also was damaged in firing the gun.

Still, at this time, the views of men were undergoing some change, for, through the assistance of the Admiralty, I had made a slide and carriage for a 6¼-ton gun, to which I shall have again to refer. It is represented in diagram, Fig. 2, plate xxv, and my confidence in its success was beginning to have weight.

Captain Heath, for instance, thinks, in the same month, when questioned by the Turret Committee, that a 12-ton gun ought long ago to have been tried in the Channel squadron, and considers that the danger most to be apprehended will be the running-out of the gun.

Captain Key also hopes, at this time, that we shall be able to work the 12-ton gun with 16 men, but expresses similar fears concerning the running in and out; and Captain Preedy, who had commanded the Hector, one of the iron-clads of the channel squadron, informed the Committee that "the other day we had great difficulty in running the "gun in with 22 men on the train whips and tackles attached to the "carriage, the ship only heeling over six degrees; but the fact of "firing the gun I have no doubt would have brought it in. Why I "alluded to running-in was this, the ports of these iron ships are low, "and if you get a gun out and cannot get it in again, it would be a "very serious matter in a seaway, for you would ship such heavy seas "that it would become a very serious matter."

And Captain Hornby, in concluding his evidence, gave a very similar opinion.

It will be seen from all this that, though we now talk familiarly of working 12-ton guns in a seaway, it is only very recently that the most sanguine, timidly hoped to accomplish the task, and the less hopeful, who had seen the 68-prs. in a seaway, looked at by the sailors from a distance like some savage animal dangerous to approach, pronounced it an impossibility.

The month after this evidence was given my carriage and slide for a 6½-ton gun were placed in the "Research." I desired that they should be prepared for a 12-ton gun at once. I said in my official letter of February 4th, 1864—"I feel sure that the 12-ton guns could "by this method be worked in a seaway with greater ease and safety "than 68-prs. mounted upon the old principle." The Admiralty, however, cautiously, and perhaps more wisely, in the face of such doubts and fears on the part of many experienced and able Officers, cognizant alone of the old system of working guns, restricted my first experiment to a carriage of the smaller size.

Now here I wish to call your attention especially to Captain Preedy's evidence, just quoted. He speaks of the danger and difficulty which had been experienced in working a 6½-ton gun in a seaway, and in a *heel of only six degrees, with* 22 *men.* He is so impressed with this danger and difficulty, that he would not go an ounce over a 6-ton gun for the broadside, and yet in the very next month, my carriage and slide for a 6½-ton gun were worked in *a roll of seven degrees with* 9 *men—quick firing,* with the greatest ease and safety.

Previous to this, the Admiralty had given authority for the commencement of the 12-ton gun-carriage and slide. They had seen the 6½-ton gun-carriage and slide in Woolwich Dockyard early in 1865, and felt justified in authorizing the further expenditure. The arrangements for experimenting with the larger carriage and slide were not, however, completed until the latter part of last year, when they were put on board the "Minotaur."

It is necessary, however, that I should here retrace my steps. My course was not so easy and pleasant as may have appeared from my correspondence with my Lords of the Admiralty.

By existing regulations and arrangements, the Navy does not make its own carriages and slides, any more than design its own guns.

My proposals were, in regular course, submitted to the War Department, and the officers of that department having had the advantage of my plans and seeing that I had introduced the word "American," in reference to the use of compressors in *turrets*, thought that it would be better to improve on what they chose to consider this "*American*" notion to giving a trial to my system in its integrity. I trust you will pardon my being a little bitter here. I don't like the system of improvement on other people's ideas by Committees appointed to test the value of inventions, and I believe it will generally be found to lead to what happened in this case.

My carriage and slide when thus improved upon, but with some of its most important features omitted, was sent to the "Excellent" for trial, and the report on them was—"that the compressor did not act, though, to all outward appearance, in working order; and on January 29th, during practice, without the least warning, ceased to act,"—"that no safe conclusion can be drawn from experience in the United States, as their guns are heavy and fired with low charges"—and that "this form of compressor had been abandoned in the American navy."

On the communication to me of this report, I called attention to the fact, that it was not *my* notion which had been tried, but the American notion, improved upon by a Committee, and thereupon orders were given

that I should carry out my own notion in my own way, in Her Majesty's Dockyard; and when I have concluded my history of the broadside 12-tonners, I think you will agree with me, that it was at least a step towards the solution of the problem.

My carriage and slide for a 6¼-ton gun were made, and proved successful, beating the improved Arsenal carriage with its new plate-compressor and eccentrics as well as the *then* service-pattern carriage (Plate xxv, fig. 1) on every point, as seen by the following records of the firing:—

No. 1.

REPORT OF FIRING WITH CAPTAIN SCOTT'S AND OLD PATTERN WOODEN CARRIAGE, JUNE 2ND, 1865.

Guns pointed at a ship at a distance.

No. of crew (Scott)..... 9
Do. wooden carriage.... 19

Rounds.	Times. Captain Scott's.	Times. Old wooden carriage.	Remarks.
	m. s.	m. s.	
1	" "	" "	
2	1 00	1 33	Both guns single shot. 20 lb. charge. 2° elevation.
3	0 48	1 25	Captain Scott's carriage. 14 rounds in 11m. 32s. (Interrupted.)
4	0 56	1 22	Old wooden carriage. 10 rounds in 11m. 07s. (Interrupted.)
1	" "	" "	Captain Scott's carriage. Rear compressor just touching; fore compressor not used. Recoil to a moderately taut breeching each time.
2	0 40	1 01	Old wooden carriage. Right rear compressor carried away. Slide very much injured. Left rectangular pivot bar cracked across the hinge.
3	0 59	1 03	
4	0 53	1 38	
5	1 10*	1 18	
6	1 00*	1 11	
7	0 45	1 03	
8	0 53	1 03	
9	0 50	1 28	
10	0 51	1 22	
11	0 50		
12	0 49		
13	1 02*		
14	0 49		
	11 32	11 07	

* In these rounds trigger line came unhooked, causing mis-fire.

No. 2.

REPORT OF FIRING WITH CAPTAIN SCOTT'S IRON, AND NEW PATTERN WOODEN CARRIAGE, 3RD JUNE, 1865.

Rounds.	Times.		Remarks.
	Captain Scott's iron carriage.	New pattern wooden carriage.	
	m. s.	m. s.	
1	" "	" "	Captain Scott's iron carriage. Fired 10 rounds in 6m. 32s.
2	0 41	0 39	New pattern wooden carriage. Fired 10 rounds in 6m. 53s.
3	0 42	0 48	Distant charges 25 lbs., and single shot. Elevation 5°.
4	0 43	0 42	
5	0 48	0 42	Captain Scott's. Fore compressor not used; rear one touching. Recoil to a moderately taut breech each round.
6	0 50	0 51	
7	0 40	0 42	New pattern wood. Recoil to a taut breech each round.
8	0 42	0 51	
9	0 46	0 41	Captain Scott's worked with 9 men.
10	0 39	0 57	New pattern wood, worked with 19 men.

Besides the successful issue of this competition with the improved carriage, specially prepared to compete with mine, I had the further satisfaction to find that both the Officers of the ship, and the men who worked the guns were equally in favour of the wrought-iron carriage. The crews of the guns mounted upon the improved and upon the service-pattern carriages, ascribed their defeat to the superiority of the iron carriage, and wished to be allowed to work it in turn with its proper crew.

Subsequent to these trials, some of which are recorded in tables 1 and 2, further experimental firing, from the same carriages, took place at Portland and was thus reported upon:—"Judging, however, from the performance of Commander Scott's carriage, at anchor and in smooth water, I think its superiority over the other carriages in its indestructibility, power of control, training, elevating, and the smallness of its crew (9 instead of 19), is very manifest.

"All the wooden carriages exhibit, in a greater or less degree, symptoms of weakness, whereas Commander Scott's seems to improve by use."

The final report of October, 1865, stated that the simplicity of the moving parts of Scott's carriage has caused the carriage and slide to be worked with perfect confidence by the men, and that the carriage

and slide possessed the special advantage of doing away with the necessity for the usual long and harassing drill.

In the meanwhile the plate-compressor and eccentrics were adopted, and, at the same time, the rear racer, which formed part of my plan. The front rollers on the slide, which had been shown in my drawing of February, 1864, and which were described in this theatre on March 2nd, 1863 (see Royal United Service Journal, vol. vii, page 92), were adopted for broadside slides on September 3rd, 1864, and the slide was of a somewhat similar pattern to that shown in Fig. 1, plate xxv, except that eccentrics were applied to its rear rollers for training. The plate-compressor is shown in Fig. 3, plate xxvi, under the head of compressors.

The improved carriage which competed with mine, and to which this compressor was affixed, is somewhat similar to the service carriage shown in Fig. 1, plate xxv.

The state of the gun-carriage question and the improvement made during late years in the mode of working guns, will be more clearly shown by a slight sketch of the past, up to the date of my first competition in the "Research."

A compressor (Fig. 2, plate xxvi), called Ferguson's, had been in use since 1858, but does not seem to have latterly given very satisfactory results, for we find that in August, 1863, the Ordnance Select Committee state, that the charge of the 9-inch smooth-bored gun "had to be reduced" from the 33 lbs., proposed by Sir W. Armstrong, "to 25 lbs., on account of the recoil," and they add, "that wrought-iron guns might be made lighter than they are, or be used with heavier charges, if the recoil could be more effectually checked."

And in the same Committee's report of the previous month, it is stated in respect to this 100-pr. smooth-bore, that "Sir W. Armstrong originally contemplated a charge of 33 lbs., with which 80 rounds were fired without apparent injury to the gun, but this charge proved too great for the carriage, which broke three times under it. On one occasion, when fired on a naval slide and carriage with this charge, Ferguson's compressor and an inside compressor (Fig. 6, plate xxvi), being used, it recoiled 6 feet off the slide."

That the need of a good compressor was urgently felt and could *not be obtained*, is clear, for at the end of July, 1863, Sir W. Armstrong, in answer to the Committee's enquiry, states, that "he is not prepared with any plan of compressors for more effectually controlling recoil."

I think I have now shown that not only was there no good naval carriage, but that its want had occasioned the charge of the 100-pr. to be reduced below efficiency, viz., from 33 lbs. to 25 lbs. This charge lessened the initial velocity of its shot more than 200 feet per second; and as a reduction to a 20 lb. charge was in prospect, with a proportionate diminution in the charge of the 12-ton guns, I thought that at last there was surely a "rowlock" for a *seaman's* oar; and hence, at the end of 1863, my propositions of 1862, with respect to the mounting of very heavy guns, were again brought forward and submitted to the naval authorities. With the results of that submission you have already been made acquainted. Shortly before my drawings had been sent

forward, an attempt was made to supply the want of a good broadside carriage. The result was the spider or Jim Crow carriage, which proved, however, far too nimble for poor Jack's safety, and has since been converted into a land service mounting.

It is now, however, necessary to describe the compressor which followed the Ferguson's, and also the plate compressor which was recommended to be adopted for all slides in July, 1865, only one month after its first trial against my compressor in the "Research."

In the old system of slide carriages for revolving guns, *two* compressors were applied for the 68-prs.; but when the 100-pr. smooth bore, firing a larger charge, was introduced into the service as a broadside gun, another compressor was added on each side of the carriage, making four compressors, as shewn in Fig. 1, plate xxv. These could not possibly be tightened alike, and hence there was great chance of that which bore the most strain being carried away.

This frequently happened, and at best these compressors are very difficult to manage, and uncertain in action. An inside compressor (Fig. 6, plate xxvi) was then introduced as an auxiliary, making five separate compressors, requiring five men to work them These compressors were used in 1864 on both the 100-pr. and 12-ton gun-carriages (see Figs. 1 and 6, plate xxvi), but were being gradually displaced by the plate compressor towards the end of 1865; but the charge of the 100-pr. has not been increased.

The competition in the "Research," and the labours of the Turret Committee, seemed to have turned public attention to the improvement of gun mounting, for now I had competitors for the 12-ton gun-carriage and slide. I worked at my single carriage and slide in Woolwich dockyard, and the committee worked at their various ones in the Royal Arsenal at the same time.

I will now describe how these systems turned out when tried in the "Minotaur." But first let me give you some of the particulars of my competitors' plans, which will hereafter be more particularly described:—

1. The Arsenal wrought-iron carriage and slide.
2. The improved pattern, wooden carriage and slide.
3. Another improved pattern, wooden carriage and slide.

1. *The Wrought Iron Carriage and Slide.*—To this was affixed, 1st, the plate compressor, which was removed before trial; then a holding-down compressor (Fig. 4, plate xxvi), which broke down after a few discharges, allowing the gun to recoil nearly clear of the slide. 3rdly, a self-acting compressor (Fig. 5), which entirely failed. This mounting was trained by tackles.

2. *The Improved Pattern.*—This was fitted with the plate compressor, which failed to arrest the gun, and left great part of the recoil to be checked by the breeching. The training was done by Mr. Cunningham's chain gearing (in lieu of the winches previously used on board the "Minotaur"), and single chains were, immediately preceding the trial, put on by Mr. Cunningham to run the gun in and out.

3. This carriage was provided with a new arrangement of elevating gear, and had a rifled gun mounted upon it. The self-acting com-

pressor of new pattern fitted to it, proved a failure; and hence tapering the sides of the slides, in imitation of my wooden baulks, was resorted to, but without success.

The competition was thus ended by the failure of the compressors, and of the other gear which competed with mine. The iron slide of the Arsenal gun was found to have become bent. During the trials which took place a short time previously in the "Minotaur" with a 12-ton gun, mounted upon an improved wooden carriage and slide, the quickest firing obtained was ten rounds in 11′ 7″. and this was considered remarkably quick, being much faster than the firing from a similar gun in a turret.

With Scott's carriage and slide, and a crew that had never worked together before being sent to the "Minotaur," or had ever *seen* a 12-ton gun fired, the first ten rounds that were fired were completed on

January 17th, 1866, in	8′	54″
2nd. Four rounds, slow time, rolling from 4° to 5° each way	4′	20″
3rd. Three rounds independent, slow	1′	37″
4th. Four rounds, slow time, rolling 8° to port and 6° to starboard	3′	3″
5th. Five rounds, quick, rolling 4° to 5° each way	3′	10″
6th. Ten rounds, quick	6′	18″
7th. Ten rounds, slow	8′	28″
8th. Ten rounds, slow	8′	13″

On January 18th (the next day) some rounds were fired with the gun double-shotted, with the full 40 lbs. charge, but although only one compressor was used, the gun did not recoil to a taut breeching. The quickest firing on this day was—

Ten rounds, quick, in	5′	58″
Twelve rounds, quick, in	6′	32″

On February 2nd, the third day's trial, full 40 lb. charges being still used, the firing was as follows:—

1st.	Ten rounds, quick, in	5′	45″
2nd.	do. do.	5′	38″
3rd.	do. do.	4′	48″

Men changed rounds twice, same captain of gun retained.

4th.	Ten rounds, quick, in.. ..	5′	58″
5th.	do. do.	5′	25″
6th.	do. do.	5′	13″
7th.	do. do.	5′	1″

The final trial—the other gun-carriages being *hors de combat*—was to test the strength of Scott's racers, and the power of his compressors, by firing the gun at the top or sharpest part of the roll. The front pivot-block was let go, and the hook under the front racer slack, so that the whole shock, &c., was taken by the racers only. The firing of 19 rounds was as follows, with only one compressor, and breeching never taut:—

1st.	Ship rolled up and gun fired at		..	$2\frac{1}{2}°$
2nd.	do.	do.	..	$4\frac{5}{8}°$
3rd.	do.	do.	..	2°
4th.	do.	do.	..	4°
5th.	do.	do.	..	1°
6th.	do.	do.	..	5°
7th.	do.	do.	..	$7\frac{1}{2}°$
8th.	do.	do.	..	$3\frac{1}{2}°$
9th.	do.	do.	..	2°
10th.	do.	do.	..	(?)
11th.	do.	do.	..	5°
12th.	do.	do.	..	$5°\frac{1}{2}$
13th.	do.	do.	..	6°
14th.	do.	do.	..	$6\frac{1}{2}°$
15th.	do.	do.	..	$10\frac{1}{2}°$
16th.	do.	do.	..	7°
17th.	do.	do.	..	$6\frac{1}{2}°$
18th.	do.	do.	..	10°
19th.	do.	do.	..	5°

The result astonished every one, and it was publicly stated by the Officer who conducted the experiments, that Commander Scott's carriage had come out "most triumphantly." And it was then recommended that some form of the American compressor should be adopted, which, judging from the carriages subsequently made, seems to have meant that the features of Scott's compressor, with its double action and lever arms, and its frictional surfaces which had been so carefully worked out and so successfully applied to *slides*, should be imitated.

The question was now settled; there seemed no room for another invention; but still the opportunity was tempting. People may ask the question, "What's in a name"—but there is a good deal in a name. Commander Scott's name, for instance, does not command the same attention as Sir W. Armstrong's. Think of the figure I should have cut if Sir William Armstrong had been the first to devise the method of working heavy guns in a sea-way, and I had pretended to improve upon his idea! But Sir W. Armstrong's modifications upon my carriage and slide were at once received as undeniable improvements.

These modifications were the substitution of iron for wooden baulks and an inside breeching of rope to stop recoil, in lieu of the gradually tapered baulks of wood to absorb it. Sir William further added to my plan of compressor a self-acting arrangement, differing little from that proposed by me in 1864 (See Fig. 12, plate xxvi), and in place of my endless chains for running the gun in and out, applied a rope (Figs. A and B, plate xxviii).*

Sir William's elevating gear was similar to that first introduced by the carriage department, but far more strongly and better made; and his carriage was of the box-girder construction.

The Armstrong slide was of double T-iron, admirably rolled, and was fitted with the new eccentrics.

* The proportions in this plate are smaller than those in Plate xxvii.—Ed.

This slide worked upon two racers, and had a third laid down to support its front.

The Arsenal also sent a slide of double T-iron, fitted with my running-in and -out chains, slightly modified, and fitted with five wooden baulks of smaller dimensions than mine. The compressor was also similar, but weaker, and the shaft was cut into two parts, which further reduced its strength.

In the carriage, the single-sided construction was adhered to, but the elevating gear was fitted with a wheel on one side in order to attain that nicety of aim which was found to be impracticable with lever handspikes, whose jerky and uncertain action, the eye could not follow.

The times of firing were as follows:—

Scotts's quickest	10 rounds,	10′ 45″;	other 10 rounds,	11′ 25″.
Armstrong's	do.	13′ 21″;	do.	15′ 32″.
Arsenal	do.	15′ 41″;	do.	gearing broke.

In the "Minotaur," ten rounds were fired from Scott's gun-carriage in 4′ 48″, and deducting the extra time alike required for loading all the guns with heavy, elongated shot, viz., 6 minutes, the relative times of performing the other operations would be:—

Scott	4′ 45″.
Armstrong	7′ 21″.
Arsenal	9′ 41″.

These figures may therefore be fairly taken as representing the comparative facility afforded by each of the gun-carriages, for working them.

Unfortunately, the weather was too fine to fully develope the advantages which were so apparent in my mounting, when there was any motion in the "Minotaur;" and hence the competition was closed without any trial of firing in rolling or at the top of the roll. Such a trial would have afforded conclusive evidence as to the holding power of Armstrong's modified iron-compressor, and proved, in some measure at least, whether Professor Airy's demonstration of the intensity of the shock of one hard metal jarring against another, is borne out by practice. In facility and quickness of training by tackles, Scott's gun-carriage had a great advantage over both its competitors; and in running the gun in and out its gear performed the operation in 10″; while more than a minute was occupied by the Arsenal pattern, and more than two by Sir W. Armstrong's.

My elevating gear moved the gun with great steadiness, and quite as fast as the eye could follow, and, as it never ran down, the elevation was always certain in quick firing.

My gun had a preponderance of 6 cwt. in the breech; the two other guns had no preponderance, though how such guns can be elevated or depressed by quoins, if the gear be damaged, is a difficulty not yet solved.

The gun upon my mounting was several times fired with its muzzle

above the port, without injury to the elevating screw; but a further description of the mode of working will be found at the end of this paper. It is therefore only necessary to mention in this place, that with the shortest of these competitive slides the muzzle of my gun was a foot further outside the port, than the muzzles of either of the other guns, and that the arrangement of my racers, &c., while affording greater training with a smaller port, assisted in preventing so heavy a jar, as was noticed on the discharge of the guns mounted upon the Armstrong and Arsenal carriages. Behind the latter, the deck was in fact pressed down one-quarter inch by the shock.

The competition was concluded after 60 rounds from the Armstrong and Arsenal gun-carriages, and 70 from mine, which, with the 200 previously fired, made a total of 270 that my mounting had withstood, without the slightest appearance of damage or strain. Subsequently to the close of the competition, viz., on May 30th, 1865, the teeth of my training racks were tested by lifting up 250 lbs. shot, and letting them fall, and passed through this ordeal with credit, as also did the training machinery when tested against tackles on the same day by the Committee.

My gun-carriage was fitted for training, either with tackles (see Fig. 1 *e* and *f*, plate xxix), by single chain (Fig. 1 and 1*a*), or by rack and pinion (Fig. 1, plate xxvii).

I think the above is a fair statement of what took place, but the *Times* newspaper, immediately after the trial, considered it probable that neither plan would be adopted as a whole, but that the best features of each would be *improved* upon, and the *Times* reporter was right.

The Gun-carriage Committee recommended the adoption of racers of similar size and width with mine. They also recommended my box-girder form of carriage, and trucks nearly approaching mine in size, and similarly coned, with my running-in and -out gear; but accepted Sir William's compressor as an improvement on mine, doing away with the inner breeching, which is, I think, the safeguard of his compressor, and one of its most valuable parts. His elevating gear, and his modifications of my compressor are, however, to be reversed, and rollers and trucks of the size used by me, but attached, or rather detached, in the mode employed by Sir W. Armstrong, are to be adopted; the position of the lever which secures the elevating gear from running down is to be changed; my running in- and -out gear is to be employed, but is to be caught in an untried manner; and various amalgamations in the bollards and transporting irons upon the slides are to be made, and this amalgamation is to be called "The Committee Carriage."

I have now brought the story of the gun-carriages to the present date. If I have dwelt much upon my own difficulties, do not leave this theatre with the idea that I am uttering the complaints of a disappointed man. Do not think for a moment that I am discouraged. I confidently predicted, when others doubted, that 12-ton guns could be worked safely and with rapidity in a heavy sea. I now predict that when tried in a heavy sea, and with continuous discharges, my

gun-carriage will unmistakeably beat Sir W. Armstrong's, as well as the amalgamated carriage of the Committee.

Details of the Working Parts of the Competitive Gun-carriages, with the Mode of their Construction, &c.

Training.

Training heavy broadside guns by chains seems first to have been applied on board H.M.S. "Excellent," in the latter part of 1865.

As fitted there, the purchase was on one side of the gun, and the chain led as in Mr. Lynn's plan, the friction was consequently small, and the ease of training very much greater than that by tackles, which, as applied in the end of 1864 to a 12-ton gun in the "Excellent," required the full complement of twenty-four men to work the gun slowly.

In the "Minotaur," in December, 1865, Mr. Cunningham led his chain round sheaves on the deck, and took the purchase up to the ship's side to be more out of the way of the other men's operations, but the friction was then considerable; little, if any, advantage in power was gained over tackles fitted on the usual plan. Mr. Cunningham's chain is shown in Plate xxix, figs. 3, 3*a*, and Mr. Lynn's, which has a shaft under the deck, in the same Plate, figs. 2, 2*a*; the ends of the chains in both these plans being fastened to the slide. Neither plan requires any lengthened description, as the mode of working is apparent, and it is also sufficiently clear from the diagrams that the chains, as fitted to the guns in the two adjoining ports of the "Minotaur," on Mr. Lynn's and on Mr. Cunningham's plan respectively, were in the way of each other, each chain preventing the extreme training of the gun next to it. It is likewise evident, that any chains stretched over the deck, are much in the way of bringing up powder and shot to the gun.

The movement of these particular chains, especially the lengthened one of Mr. Cunningham, and the sudden tightening—either in a roll or in training the gun—of the slack part necessarily left for play, would always be dangerous to the legs of the crew, and probably cause serious accidents to the men carrying up 250 lb. projectiles to the muzzle of the 12½-ton rifled gun. This duty would be more critical at night, for the men in a roll might then, inadvertently, put their feet against these chains for steadiment. If chains be used at all, the least objectionable is probably the straight chain and oscillating pitch-wheel (Plate xxix, fig. 1, 1*a*), as it does not interfere with the training of the next gun, is not in the way of the loaders, and is kept stretched in one fixed position upon the deck. The motive power also is close to the captain of the gun, which would be of great advantage in action when the thick smoke would prevent men at the side from being seen, and the noise, the voice of the captain from being heard. The arrangement of the men pointing being close to the captain of the gun is likewise obtained by my rack and pinion movement, which enables the gun to be trained and kept bearing upon the object, not only in loading and running out, but also until its discharge.

The special advantages obtained by my rack and pinion movement were precisely those in which, as Captain Key informed the Turret Committee, the turret had a superiority over the broadside. He stated "that training while loading gave great advantage to the turret," and afterwards said that, "training by machinery gives the gun in the turret an advantage;" and in the lecture given by Mr. Cunningham, in 1864, already quoted, he concludes that, "the success, then, of the discharge of a gun will depend upon the quick and steady manner it can follow a passing object," which arrangements, he believes, "can only be provided by the application of steam power."

The tackles used by me were placed and hooked in the same manner as those which were applied to my iron carriage in the "Research." They are shown in Figs. 1*e*, 1*f*, plate xxix, but both chains and tackles, however good for preventer plans of training, are inferior means of laying the gun; for the accuracy aimed at in rifled ordnance cannot be secured by their use, neither with much motion can the rapid

touch, often necessary to make the gun cover the object, be given. In the case of tackles, late experience has shown that a sea shipped through port-holes causes men to drop them and to leave the gun adrift and unmanageable.

The Racers and Pivots.

My plan of raised racers, which had been so much approved in the "Research," was again adopted in the "Minotaur," and the same racers were subsequently laid down in the "Bellerophon," but in both the latter ships the centres of the racers were let down into the deck three-quarters of an inch, and their ends raised, so as to admit of the gun's being trained round on an horizontal plane. The edge nearest the ship's side of the front racers was slotted to receive a strong hook (Plate xxvii, D*d*), which held the slide securely down to the deck and rendered the gun secure in any sea. In the "Minotaur," as well as in the "Research," the front of the slide was further secured by a massive metal block, working in a grooved racer; but after the trial of firing the 12-ton gun, nineteen times at the top of the roll in the "Minotaur," without this fastening, it was considered unnecessary, more especially as a special pivot-bar or flap of the same strength as the usual service elongated V-flaps had been fitted to the pivot-point in the port as a preventer.

The advantage of my racers consisted in their being employed to hold the slide, and in the power which they gave of fastening them, so as to afford the largest arc of training that could be obtained from the port aperture. They also strengthened the deck through which they were bolted, and, by means of the flanged rollers on the slide, spread the shock of discharge over a large space.

In the "Minotaur" the gun on my mounting trained 31° each way; but no gun with the V-flap and fixed pivot obtained so much as 29°.

A similar result was observable in the "Bellerophon" where, although the port was closed up from 2ft. 9in. to 2ft. 1in., the training was still 31° each way. The training of the other guns in a 2ft. 9in. aperture was only 30°.

In the diagram (Fig. 1, plate xxix) is shown the filling up of the "Minotaur's" port, which was closed on the lower side 14 inches, the corners being rounded and made much higher. The application of this important feature of my *system* of mounting had a similar effect to throwing the lower port-cill, a mean of 16 inches higher out of the water, thus adding greatly to a vessel's capabilities of fighting in a seaway.

In the "Bellerophon" the centre of the lower port-cill was filled up 7 inches, and the corners closed in the same manner as in the "Minotaur." With this arrangement about 11° of elevation were obtained by firing with the gun's muzzle above the port, and 5° of depression with the muzzle clear of the filling-piece on the lower port-cill.

Had a small half port been fitted, 7½° of depression could have been obtained in the "Bellerophon," and 9° in the "Minotaur," when wanted; but as it was, the cheap wood was knocked away when, at the last, extreme depression was given to the gun. While the wood remained, it was a protection to the loaders against the spray and sea, nor was any disadvantage found, but the contrary, from closing up the port. The rapidity of fire in the "Minotaur," with the 150 lb. ball, being more than double that previously obtained, and the quickness in the "Bellerophon," with the 250 lb. rifled shot, being equally unmatched.

The Arsenal iron slide in the "Minotaur" was placed upon thin and narrow racers, only slightly thicker than those first used for 12-ton guns. It was held only by a single pivot-point on the top of the lower port cell, which was 17½ inches from the deck. This *pivot-point* was much exposed, yet on this the whole security of the gun depended, and upon it the severe shock of the recoil was concentrated, and tended to drag away the ship's side from the armour plates affixed to it.

In the "Bellerophon" the racers were considerably thicker, but were still not utilised for holding the slide, or bearing any portion of the sudden shock backwards occasioned by the discharge of the gun. The pivot-point was, however, better supported and protected, the port-cill covering it, and reaching up to a height of 26 inches above the deck.

Sir W. Armstrong's slide was supported upon similar racers, but had an additional racer under the fore-end of the slide, which seemed not to be an advantage in training; like that of the Arsenal, it was held by a single pivot-point. The usual elongated pivot V-flap was used to fasten both the Arsenal and Armstrong slides to this point in the port-cill, and was in both cases found to be much in the way of the men loading the guns. The eccentrics first used upon the improved Arsenal slide tried in the "Research," were alike applied to these slides and carriages.

In training the slides, the defect of their always dropping the breech of the gun on slacking up and removing the eccentric levers before firing, and of generally letting it slip to the right or left, was observable, and the inability of using the slide-eccentrics to lift the slide when the gun was run in, was a further drawback to their use. The discharge of the gun also frequently upset these eccentrics, and put them out of working order.

The Elevating Gear.

My arrangement consisted of a screw working through a box, fitting inside another box, which was fastened to the gun. These boxes had a washer interposed between their surfaces, and the outer box was open at the bottom; hence when the gun was fired with its muzzle above the upper port-cill, the outer box lifted several inches up from its resting-place on the inside box when the muzzle dipped under the port-cill, and then dropped easily down again upon the washer on the top of the inner box. By this contrivance the weight of the breech of the gun was received without any damaging shock, and the jar of the discharge was likewise absorbed. Any *fixed* elevation could also be given and maintained with certainty in bombarding.

Motion was communicated to the screw through two bevelled wheels, suitably supported upon the bottom of the carriage, by means of handles worked upon each side, an arrangement which enabled a rapid touch to be given to the elevation in case the captain of the gun found that in rolling up or down, his sights would not come on with the object to be fired at.

The Arsenal elevating gear was somewhat more complicated, and consisted of a band under the gun, worked by a toothed rack and pinion, to which motion was communicated by means of gearing on the upper side of the carriage. The teeth of the rack being of brass, soon gave way, and the wheels became broken by the jar of firing.

The Armstrong elevating gear consisted of a similar rack and pinion, but of greater size, and of wrought iron. The lever for securing the elevation was on the lower side of the pinion, and, falling from the shock of firing, allowed the breech of the gun to move from its position.

In firing with the gun's muzzle above the port, the band was slackened from the gun; hence although the gun could be fired in this position with its breech resting upon the bottom of the carriage, a marked quoin or other means would have to be employed to give any intermediate and high elevation, which required the muzzle of the gun to be above the port. The shipping and unshipping of the lever elevating handles before firing was also found to be disadvantageous.

Running-in and -out Gear.

My gear consisted of two endless chains, stretched over two pitch wheels on each side of the slide, with a screw arrangement for tightening the chains. When the gun was required to be run in, the outside part or toes of the compressor-levers were pressed against the lower part of a box (Figs. 1 D and C, plate xxvii), which was serrated on its upper edge, so as to fit between the pins of the chain links, and press them up against the serrated edge of the upper box.

By this means several of the pins of the chains are securely held by the whole force of the compressor, and as both parts of the box which clutch them, are attached to the carriage, it is only necessary to turn the purchase at the rear end of the slide, to draw the gun in or out. When either operation is finished, the handle of the

compressor is turned, and the inner part or heel of the compressor levers then perform the work of compressing.

Thus one compressor performs the double duty of holding the gun on recoil, and of clasping the chains on both sides of the slide together, with equal certainty and security; and this gear, being always in place, and out of the way of every other working part, was at once adopted, as overcoming the chief difficulty previously experienced in working heavy guns.

The Arsenal gear also consisted of two chains of insufficient strength, which had to be caught by hand-levers, worked independently on each side of the slide. The result of this arrangement was, that the men were unable to work together, and the strain being generally borne by a single chain, soon broke one of them.

The Armstrong gear can be best understood by a reference to the diagram, Figs. A, B, D, plate xxviii. The running-in gear completely tired out the men, and hence during the competition, the gun was loaded at the point to which it recoiled, the men not unfrequently standing out on the port-cill to put in the powder and shot. Had there been much rolling, or any sea running, the men could not have loaded in this position; and even in this smooth water competition, it was attended with some risk. The running out was performed by tackles in the usual manner (see Fig. A, same plate).

Running in and out—"The Eccentrics."

For Scott's carriage, eccentrics which had a stop to allow them to pass the centre and remain fixed in that position, were devised. This prevented the necessity of the men's holding on to them in running in or out; but the arrangement also allowed the crew on each side to hold on by the ropes which were attached to the ends of the levers of the eccentrics, if required, and so keep the eccentrics ready to drop the carriage off its rear rollers or trucks.

The levers which work the eccentrics are upon the *sides* of the carriage, and as fitted would prevent injury to the crew in case of the gun going off in running out. Should the eccentrics be slacked up, the carriage would drop upon the slide, with a surface of wood everywhere touching a surface of iron, as dropping the rear of the carriage, lifts the front trucks off the slide; and as both these surfaces are rough, there would then be an absence of sliding sufficient to keep the carriage and gun from moving in a roll. The lever handles are fitted with bands round the drumhead of the eccentrics, which hold them securely when the levers are let drop out of use.

In consequence of these arrangements, every moving part of the mounting is in place, ready for use, and No. 1, having no mechanical labour to perform, can give his whole attention to keeping the gun pointed upon the object, which can be done by means of the rack and pinion, so steadily as not to interfere with the loading. The requisite elevation, in case of a change in the heel of the vessel, can also be given with the same ease and steadiness, and all these operations can be performed simultaneously.

In the evidence taken before the Turret Committee, Captain Powell speaks of the captain's undivided attention being given to the "pointing," as an advantage of much value to the turret.

The Arsenal carriage eccentrics, both in the "Minotaur" and "Bellerophon," are those now adopted into the service in the place of the Gordon eccentrics and levers, which had been so long used with revolving slide carriages, and which were also applied to broadside slide carriages until after the trial of the "improved" carriage on board the "Research" in June, 1865.

The Gordon levers, shewn in Fig. 1, plate xxv, were worked by the side tackles in running out, on slacking which, the carriage dropped off the eccentrics upon its blocks.

The Arsenal eccentrics are worked by lever-handles at the rear of the carriage, which compel Nos. 1 and 2 to go out with the gun, weighing down upon the handles with all or nearly all their strength. This work necessarily takes the captain of the gun (No. 1) from other duties, and obliges him to seek for his object, after removing and handing to another number his lever-handspike. In case of the guns going off

while running out, Nos. 1 and 2 would fare badly. Such an accident happily did *not* happen, but during the competition in the "Minotaur" one of the 12-ton guns went off just as the captain was laying over the breech and pushing the priming-tube into the vent. The fact of his *touching* the gun with so much of his body bent over it probably saved his life, and allowed him to escape with merely a severe shaking.

The Armstrong carriage was fitted with similar eccentrics to those of the Arsenal, but they were more difficult to work, owing to there being no platform for Nos. 1 and 2 to walk out upon (Plate xxviii B), for neither the tops of the iron plates substituted for wood baulks nor the top of the slide afforded a safe foothold. It is, I think, doubtful whether, in case of dropping the eccentric levers in a roll, the carriage would remain stationary, for its iron bottom would rest only upon a slippery iron slide.

The Compressors.

Scott's carriage is fitted with two compressors, under the idea that, however powerful and strong the working part may be, it is not safe to be dependent upon a single part. Reverting again to the important evidence given before the Turret Committee, Captain Preedy mentions the "great risk of trusting to one thing in a ship," and this was the view taken in constructing Scott's carriage, and therefore a second means has been prepared for performing every important operation for working the gun.

The fore compressor (Plate xxv, fig. 2*c*) is the more powerful of the two compressors, being placed on a higher level than the other; the upper lever arms are longer. The shaft upon which these arms work, passes through each side of the carriage and projects beyond; it is provided with a right and left handed screw, to which motion is given by turning a handle shipped upon the shaft at either side of the gun, and thus opening or closing the lever arms. This compressor is applied when extra-holding power is required, and is useful as an additional means of readily checking the gun when running in or out in a heavy roll.

The rear compressor being on a lower level than the spare one, and being also considerably below the level of Scott's proposed height of lower port-cill, would probably escape injury were the front compressor to be hit. Although the rear compressor is the less powerful, it is more important than the other, being employed to catch the chains in running the gun in or out, and being also the working compressor for holding the gun on firing. The only addition made to this compressor, to enable it to perform also the duty of clutching the chain, consists in small pieces or toes on the outside of the lever arms. These additions are seen at Fig. 1C, plate xxvii, where the compressor is shewn in section "compressing" the baulks preparatory to firing, and consequently with its toe-pieces clear of the lower box, the action of which has been already described under the head of "running-in and -out gear."

The baulks of wood upon which the compressors act are slightly tapered longitudinally towards the front of the slide, and are very much tapered in their depth. The object of this is, to allow the gun to move easily at first, from the compressors being slack, so that the sharp vibratory shock which would otherwise be given to the mounting is avoided, and the gun gradually arrested by increased friction, the whole of its momentum being *utilised* in the process. This result is much aided by the iron plates which pass between the interstices of the baulks in the slide being thicker at the bottom than at the top, so that, on the gun's discharge, they act as inclined planes to wedge the carriage closer down upon the slide and its baulks; and hence the desirable combination of the best properties of a holding-down compressor with that of a gradual and easy absorption of recoil, is attained.

There is practically a multiplication of power in this arrangement, for when by turning the compressor-handle a pressure of 1 lb. is brought against the outside of one baulk, the same force is exerted at each of the other five surfaces, making a total of 6 lbs. for frictional purposes.

The Arsenal compressor arrangement in the "Bellerophon" (Fig. 9, plate xxvi) differed from mine in the shaft being cut into two parts, which threw a very heavy strain upon the sides of a carriage, already too weak to bear the shock of the discharge. The baulks were of wood, but without taper, and in firing, as the gun warmed, it recoiled with much force upon the breeching.

The Armstrong compressor shaft was also in two parts, having on the one side a screw with a lever upon it, to regulate the amount of compression, and upon the other another screw of coarser pitch, having a handle or lever to compress with, before firing the gun (Plate xxviii, fig. C).

In case of the proper gun number omitting to pull this handle down, and so put on the compression, the lower part of the handle was caught by a projecting piece upon the slide, which pushed it down into place on the gun's recoil, and thus prevented the recoil of the gun, with a slack compressor (Plate xxviii *Aa*).

It has been already mentioned that Sir William's compressor baulks are of iron, and hence on the screwing up of the compressor by the self-acting arrangement, a check is necessarily given to the carriage, which may be found to have a more damaging effect upon its slide than the usual tight screwing up of his compressor by hand before discharge.

Construction.

The Armstrong slide is of double T-plate iron, and open at rear, but to prevent the carriage from running off the slide should the usual outside breeching carry away, it was furnished with an inner breeching, fastened to the slide and passing round, and supporting a strong wooden block, sliding in a groove. This block is placed close against the iron baulks in the slide, and serves the further purpose of aiding the compressor, for in case of the gun's recoil is not fully arrested, the block receives the shock, and, yielding, pushes against the breeching, which stretches gradually, and arrests the gun.

The carriage is of the box girder-form.

The Arsenal slide is of double T-iron, and the carriage single-sided, as shown in the sections upon Plate xxix, figs. 2*c* and *d*.

The carriage in the "Minotaur" was made in imitation of the wood pattern, with blocks across the bottom, &c. The carriage in the "Bellerophon" had an iron plate bottom.

Scott's slide is of the box-girder form (Plate xxix, figs. 1*b*, 1*c*); the end is closed. The carriage is of similar construction, and fitted with wood on its lower portion, precisely like the one tried in the "Research." See sections, fig. 1*d*.

The slide in the "Research" was of double T-iron, supported by thin plate iron rivetted against it, and its end was closed.

American Compressors.

It now only remains to describe Ericsson's turret compressor, and the disc compressor which he has applied to broadside guns.

The shaft of Ericsson's turret-compressor does not pass through the carriage, it has a single screw thread upon it, and the plates which are attached to the bottom of the carriage pass between four baulks, *which rest upon the bottom of the turret*. All these baulks are free to move laterally, and are parallel. The carriage is always upon its rollers, with its bottom plate clear of the baulks, and therefore its momentum is *not* used up for reducing recoil; this, there is only the single compressor worked on one side to check, and the result is, that the compressor cannot be unscrewed after firing without great difficulty, and a delay of two or three minutes. In the "Miantonomoh," the action of these compressors was far from satisfactory, although the charges were small.

The disc-compressor has been too recently introduced into America to have had much trial, but so much doubt seems to exist there as to its holding power, that air and water are both under consideration for use in cylinders to be placed under the slides for broadside guns to absorb the recoil.

Considerations.

I wish to point out that the most important questions suggested by this afternoon's lecture for your consideration are—

1st. The description of gun-carriage needed; whether it should be entirely of iron, and single sided, regardless of the vibration; or whether, for strength and durability, it would not be better to have double-sided carriages filed with wood to absorb the vibration.

2nd. Whether the heavy guns of the present day can or cannot be worked by the same means used for light guns a century ago, and whether it is not high time to avail ourselves of such mechnical appliances as will, with fewer men, enable us to handle the 12-ton guns with greater ease, and to use them more efficiently than was ever achieved with the long 24-pounder of 1805.

3rd. Whether the various compressors I have described indicate that we are in the track which will ultimately lead to the desired goal. In considering the matter I would request your attention to this, all parallel and side-plate compressors on parallel slides, such as that of Sir W. Armstrong's and the Arsenal, are, in my opinion, really non-recoil appliances, inasmuch as that compression and friction check the recoil, and then the force of recoil, which is in excess of the power of the friction, must be overcome by leverage compression; the blow, which is thereby delivered upon the slide and deck, must be sudden and destructive, but with tapered baulks and wedge plates, there is not only compression and friction, but the resistance of inclined planes to absorb the recoil, and that therefore much less leverage compression is needed.

The CHAIRMAN: Any questions that may be asked, Captain Scott will now be happy to answer them.

A MEMBER: I should like to know a little more about the running-in and running-out and the elevating gear.

Captain SCOTT: Diagram (see Plate, xxvii, fig. D) is an excellent drawing, which will, I think, show clearly how the running-in and out gear is fitted. I shall be happy to describe further the elevating gear, after hearing if there are any more queries.

A MEMBER: Do you use a rope sponge?

Captain SCOTT: No. I raise the lower half port as much as possible, and in the event of having to close the upper half port when the ship rolls, the gun should be loaded thro[illegible] a small scuttle, which should be cut for the purpose of letting the ends of the rammer and sponge staves pass through.

Captain HEATHORN, R.A.: When your gun is at its greatest elevation, do you find any great strain on the screw gear with which you elevate it?

Captain SCOTT: No; it was noticed that the gun jumped about very little, when fired with its muzzle considerably above the port, the breech being down upon the carriage. The gun gives 11° in this position, but a new carriage might easily be arranged for 16°. At the time I commenced my carriage it was affirmed that more than 9° of elevation were unnecessary.

Captain HEATHORN: What amount of depression?

Captain SCOTT: The depression allowed by the wooden chocks with which the lower parts of the "Minotaur" and the "Bellerophon's" ports were filled up, was 5½°, but with an iron lower half port, 9° of depression could have been given in the "Minotaur's" port.

Captain HEATHORN: What I wanted to know was to what extent of depression has the gun been already fired, so as to test the screw?

Captain SCOTT: 7½°. Do you wish me to further describe my elevating gear?

A MEMBER: Sir William Armstrong's.

Captain SCOTT: Sir W. Armstrong's consists of a band under the gun, working in slots on the inside of either bracket of the carriage, motion is given to this band by a rack and pinion, which, as the gun has no breech preponderance, raises it rapidly, the only delay being that of getting the lever handspikes into their sockets, and in clamping and slacking the stop, or paul arrangement. In case, however, further elevation or depression is found necessary, the captain must wait till the handspikes are again re-shipped, the proper elevation given and the pinion clamped, and the handspikes removed clear of the carriage, before he can fire the gun. As the elevating and training are both involved in *pointing* the gun, I may mention the disadvantage of training with

tackles. In case of the ship's heeling over, the lee guns will have a great tendency to swing in towards the lee side in consequence of the slope of the deck, and to train the gun you have to send the crew from one side to the other; whereas with machinery you have sufficient power to train the gun at all times, retaining the gun numbers on their proper sides, and thus confusion in the dense smoke and excitement of an action at close quarters would be avoided.

The CHAIRMAN: You have stated the relative number of men in the first experiment. What were the relative numbers in the last competition?

Captain SCOTT: 14 men at my carriage in the "Minotaur," and 16 men at the other carriages; there were 16 men at all the carriages in the "Bellerophon"—this number of men at my mounting being only required for hoisting-up, carrying to the gun, and loading the 250 lb. elongated shot.

The CHAIRMAN: How many were necessary for the gun-carriages, apart from the question of shot?

Captain SCOTT: Loading with the round ball you *could* work my gun-carriage with four men, and do so very easily with six men; but the other carriages in the "Bellerophon" were trained with tackles, 16 men would be, in any case, requisite for them.

A MEMBER: Did you fire round shot as well as the elongated bolt?

Captain SCOTT: We fired no round shot in the "Bellerophon." We fired round shot in the "Minotaur;" the round shot were 150 lbs. weight, the elongated shot 250 lbs. The former were lifted up to the muzzle and then rolled in very easily; the latter had to be got up perfectly horizontal, and then the studs had to be accurately adjusted to the grooves of the gun.

A MEMBER: Was the ship rolling when you run out your gun in ten seconds?

Captain SCOTT: No; but the rolling would not have stopped it; there is sufficient power in the purchase to run the gun out with the ship heeling over considerably.

A MEMBER: Will you describe your training apparatus?

Captain SCOTT: The training apparatus is simply this—there is a shaft under the gun which carries two pinions working into a separate toothed rack under the fore part of the slide, and into a second toothed rack cast in one piece with the racer under the rear. This shaft is turned by a single wheel, or else by two handles (both are fitted) at the *rear* of the slide.

Admiral RYDER: What was decided as to the adoption of your's or Sir William Armstrong's carriage?

Captain SCOTT: The Committee said, I believe, that they were practically alike; and therefore, as it was recommended to make the carriage by contract at Elswick, that Sir William's should be adopted.

Captain SELWYN, R.N.: There is one observation which I should wish to make, in order that, as I see an engineer and mathematician present, he should not go away with a false idea of what Captain Scott stated in his paper. He was speaking of the one pound applied being distributed as one pound on each surface. I did not understand that he meant that one pound was distributed upon each surface. You may increase power by sacrificing time, but you cannot make one pound exerted over one minute, any more than one pound exerted over one minute.

Captain SCOTT: I was speaking of it as a frictional power. I did not mean a multiplying power.

Professor O. BYRNE: This is the question: that the wood that Captain Scott spoke of receives all the force and passes it forwards. He does not mean that that wood does any more than iron; but it passes the force applied over the parts equably; whereas the iron passes it by a rebound, a shock. The one receives it, swallows it, passes it; the other receives it and returns it, which causes mischief. I think Captain Scott is perfectly right in his explanation, although not exactly mathematical.

Captain SCOTT: It was not certainly mathematically expressed. I carefully guarded myself against using scientific terms, and, therefore, did not go into co-efficients of friction, &c.

Captain SELWYN: I was only anxious that no one should go away from this Insti-

tation with a false idea which might have arisen from the words used. I can only add my testimony to the very brilliant results which Captain Scott has shown us, and the great pleasure with which I have always listened to his very comprehensive and sound lectures on the subject of artillery generally.

The CHAIRMAN: With your permission, I will give our thanks to Captain Scott for his very interesting and lucid exposition of this question. The great merit appears to be in the simplicity and the security, which his plan seems to me, entirely to embrace. I can well understand why the preference was given to the other carriages, although at a glance it appears to me it was not necessary to have any competition. But I have observed, strange to say, that whatever is more ingenious is that which is adopted. And though it may seem strange to say so, I have observed, with respect to inventions, that they generally adopt the most ingenious and least practical as the best. That is the only way I can explain the case with respect to the carriages, and with respect to the guns. I do wish Captain Scott every success in this matter. I think he is entitled to immense credit for the perseverance with which he has worked out this question. It is quite evident that his plans have been clearly before his mind in the first instance, and hence he would not be put off his course by the constant difficulties which have been thrown in his way.

Monday Evening, July 9th, 1866.

VICE-ADMIRAL H. J. CODRINGTON, C.B., in the Chair.

NAMES of MEMBERS who joined the Institution between the 4th June and 9th July, 1866.

LIFE.

Richardson, W. F., Lieut. R.E. 9*l.*
Best, J. C. H., Major ret. 72nd Highrs. 9*l.*
Jekyll, Herbert, Lieut. R.E. 9*l.*

ANNUAL.

Payne, J. B., Capt. 4th Middlesex Art. Vols. 1*l.*
Stanley, Hans Sloane, Lieut. ret. 16th Lancers. 1*l.*
Doxat, Charles J., Lieut. R.N. 1*l.*
Hunter, Geo. W. E., Cornet 3rd Huss. 1*l.*
Curme, C. T., Captain R.N. 1*l.*
Powys-Keck, H. L., Lieut. Leicester Yeomanry Cavalry. 1*l.*
Powys-Keck, T. B., Ens. 60th Royal Rifles. 1*l.*
Winter, Mathew, Asst. Com. Gen. 1*l.*
Shakerley, Sir Charles W., Bart., Lieut. Col. 5th Batt. Cheshire Rifle Vols. 1*l.*
Gahan, Henry, Col. late 5th W. I. Regt.
Scott, Charles T., Commr. R.N.
Saunders, J. M., Lieut. R.A. 1*l.*
Phayre, R., Lt.-Col. H.M. Bo. Staff Corps. 1*l.*
Nicholets, Geo., Capt. H.M. 27th Belooch Regt. 1*l.*
Greenhill, J. R., Assistant-Surgeon 72nd Highrs.
Barstow, T. A. A., Ens. 72nd Highrs.

SHIPS' LIGHTS AT SEA.

By Commander P. H. COLOMB, R.N.

THE most recent Board of Trade returns, tell us that collisions by night are about three times as frequent as collisions by day, and so far encourage us in placing a high value on the questions we have discussed on two previous occasions, and are to continue to discuss to-night.

They also tell us that the three most prolific causes of collision, are neglect or misapplication of steering rules; bad look-out; and neglecting to shew the proper lights. In which sentences we find texts very apposite to the particular branches of inquiry we have entered upon, and very sufficient answers to those who might be disposed to think lightly of the disease for which we are endeavouring to seek a remedy.

We may further strengthen our position by adding that more collisions occur in clear and fine weather than in a thick and foggy atmosphere, while at the same time thick and foggy weather alone, is stated to be the cause next in productiveness of collision, to those already mentioned.

One by one I propose to examine these four causes, so far as they operate at night, avoiding the question of improvements in steering rules, which are in abler hands, and confining myself entirely to what is, or, in my conception, ought to be done, with reference to lights, fixed or temporary.

I think it will be admitted that the terms "neglect or misapplication of steering rules" embrace a very wide field, and that it is probable that, had we the details of each case registered in the column under that heading before us, we should find ample scope for argument over the majority of them. We should find it difficult to say off-hand exactly in what respects the steering rules were neglected or misapplied.

Every one knows that nothing is more difficult than to balance the blame in a collision case, and if we are to judge from the casual conversations of nautical men, law and common sense come into as severe collision, as the ships which brought them into opposition.

While it is an absolute necessity that there should be a sea "rule of the road," it is also clear that there must be an exempting clause, such as Art. 19 of the Shipping Act regulations; and to my mind it seems as if the heading "neglect or misapplication of steering rules" would be more correctly rendered as "one ship's acting on the rule of the road, and the other on the exempting clause."

Considerable judgment is required when danger of collision approaches, whether the circumstances justify a departure from the rule of the road; but, taking the average of human nature, we should say that imminent danger is not conducive to clearness of judgment.

Captain Heathcote, as I understand him, wishes, by his method of placing lights, to give persons in charge of ships at night the greatest possible time for the formation of their judgment, by the immediate detection of the course of any approaching steamer. He seems to think—and I agree with him—that, give a man time enough to think of the proper thing in a doubtful case, and the proper thing will be done, and collision avoided.

I have no doubt myself that were his plan generally adopted, seamen's eyes would, in a few years, get quite accustomed to estimate the course of approaching steam-vessels, and men would have time to use their common sense, so as to avoid even an approach to a collision; they would not then, as is now too often the case, hesitate till the time for action is past, and then fall back on that refuge for the destitute, the Act of Parliament, calling out "hard a-port!" and defying fate with the law on their side.

If a man in charge of a ship at night could only be sure of the exact position and course of his approaching neighbour the moment she was seen, how calmly he could make his arrangements for clearing her! But every seaman knows the anxious and painful moments which elapse between the report "a light on starboard bow," and the attain-

ment of certainty as to the approaching ship's course and distance. This state of doubt gives the judgment its first blow; the longer it is in coming to a conclusion, the nearer grows the danger, and the less chance is there that the judgment, when formed, will be correct.

These circumstances lead to cases when it is not possible to get time for reflection, where collision becomes so imminent that unless both ships obey the guidance of one common thought, disaster will result.

For cases of this kind Captain Bolton and I have prepared our "Warning Lights." It has always seemed to me that if, when the danger of collision is very near, one man could assume the direction of both ships for the moment, the danger would pass away.

These warning lights, of intense brilliancy, and a power capable of sending their light 20 miles, have been introduced by the inventors to meet the above cases.

They are coloured red, white, and green, and represent efficiently during the thickest weather, the present port, starboard, and mast-head light, which are then invisible.

If a ship, close-hauled, lying-to, or otherwise not under sufficient command to avoid collision, perceives another ship coming down on her *starboard* side, and likely to foul her, she will instantly burn a *green* warning light. This will immediately alarm the approaching ship, and will cause her to *starboard* her helm, and so pass harmlessly astern.

A ship being approached by another on her *port* side will burn a *red* light, when the approaching ship will *port* her helm to go clear.

A ship may also, on approaching another end on, or nearly so, burn a *red* light to shew she is putting her helm *a-port* and to warn the other ship to do so likewise; a *green* light to shew she is putting her helm *a-starboard*, and a *white* light to shew she is keeping her course.

The *white* lights are also to be burnt by vessels at anchor when ships are approaching them.

The whole process of using these *warning* Roman lights, is therefore simply applying powerful lights to carry out to their full extent the Board of Trade Regulations for preventing collisions.

The lights are perfectly safe to handle, but are so constructed that they will ignite *instantaneously* when required.

Water-tight boxes are supplied with these lights, to be fixed on deck in convenient places so that they may always be at hand when wanted. The boxes are made to contain half-a-dozen, or one dozen of each colour.

The *red* lights are on the left hand, the *white* lights in the centre, and the *green* lights on the right hand.

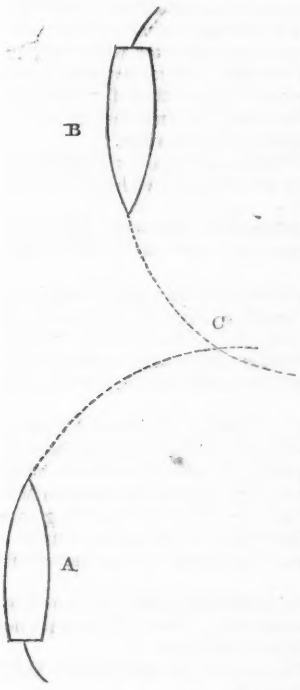
The *red* lights are further distinguishable *in the dark*, by having *one* ring on the handle, the *white* lights by having *two* rings, and the *green* lights by *three* rings.

To use them, it is only necessary to open the box, take out the light of the required colour; remove the cap, and draw out the wooden plug quickly, the light will instantly burst into brilliant flame.

Now, if A, coming nearly into collision with B, could tell her which way to put her helm so as to agree with the movement she herself was

making, less presence of mind on either side would be required, and there would be much greater certainty of avoiding accident.

Fig. 1.



Let me take a single case, illustrative of the uses of these lights.

A and B discover each other on their starboard bows. B, being possessed of better eyes, and keeping a sharper look out than A, forms an idea of A's course, and, following his common sense, starboards his helm. But B's lights are both bad, and badly placed, so A, labouring under his other disadvantages, is very far from clear about B's course; he therefore goes according to Act of Parliament, ports his helm, and comes into collision about the point C. Poor B of course goes to the wall in the Admiralty Court, or under a Board of Trade enquiry, because it is difficult to get at any distinct fact except that A ported her helm and B did not. B, profiting by his experience, practices calling out "hard a-port" as a legal solution of every difficulty and no doubt finds it answer. Now, if B, being quite certain of A's course, and of the proper mode of avoiding her, namely by starboarding his helm, had been able to announce to A, by burning a green warning light, that she was doing this, or about to do so A's doubts would have vanished, and moreover, had she now ported her helm and brought about a collision, B would prove having displayed the warning signal, and A would legally as well as actually suffer damage. Or again, if A, being in doubt, ports her helm according to regulation and burns a red warning light, B may stop, or heave to, or port his helm alone, being certain of A's proceedings, but he assuredly will not put his helm a starboard as we have seen him do.

The advantage of using *red* and *green* lights as signals in preference to others are manifest enough, as "red and port" and "green and starboard" are irrevocably connected in seamen's minds, and instinct alone will make a man call out "hard a-starboard" if a powerful green light appears suddenly before him at sea.

Equal in its evil effects with the misapplication of steering rules, stands, according to the returns—"Bad look out." Here again we have a statement to which there are, as there were in the last, two sides. As a man may justify himself when charged with

misapplication of steering rules, by appealing to the exempting clause, so a man, charged with keeping so bad a look out at night as to bring on a collision, may justify himself by declaring that his opponent neglected to shew the proper lights, and that that was the cause of the ship not being seen in time, and not his assumed inefficient look out. And if the matter comes to trial there will be uncommonly hard swearing on both sides, rendering the ultimate decision almost a matter of hazard. One feels some curiosity when one sees it stated that 421 casualties by collision occurred in the six years ending December, 1864, which were caused by bad look out, against 168 which were caused by "neglecting to shew the proper light,"—I say one feels some curiosity to know by what process such conclusions were arrived at, and how many of each class are in their wrong columns. Board of Trade enquiries into collisions are naturally rare, as those cases come more readily under the jurisdiction of the Admiralty Court in the shape of actions for damages. When, however, they do so come—when the "Mary Jane" runs into the "Sarah Ann," takes her bowsprit out of her, and brings an action for the loss of her own port cat-head—the cause, after very elaborate argument, is commonly reported to end with the stepping in of the nautical advisers of the Court who are "of opinion that the 'Sarah Ann' was to blame," and the plaintiff gets his damages. Now when cases of this nature turn upon a charge of "bad look out" on the one side, and "neglect of showing the proper light" on the other, one feels anxious to know how the nautical advisers of the court come to a conclusion on the merits. Are the accused lights brought into court and examined? and if so, is there any one called in, competent to examine them?

We had it stated here the other night, by a high authority, that a great deal of ignorance on the subject of lights prevailed in the Royal Navy; that statement I can most fully endorse, and I imagine that such ignorance must extend still more widely in the merchant service. Nor need we be very much surprised at this, when we learn that many of the lamp-makers themselves are profoundly ignorant of the simplest optical laws, and understand very little indeed of the nature of the wares they deal in. When the Board of Trade, or the Admiralty Court decide that the accusation of not shewing the proper light is unfounded, who examines the lights to see that they are "proper?"—that is, according to regulation. Believing as I do, in the wide-spread want of knowledge on the subject, and seeing the very inefficient and improper lamps which receive a ready sale at all our ports, I am tempted to believe that very little examination, if any, takes place. And until it is distinctly shown that the law will not uphold a ship carrying improper lights, we need not expect that improvement in them, which is now so much needed.

In the case of the "Samphire" and "Fanny Buck" which has been once or twice quoted here, a great deal of evidence turned on the point whether the "Fanny Buck" had any *green* light showing, and, as might be expected, such evidence was conflicting. I did not make out whether the "Fanny Buck's" lamps were brought into Court, but I

could not help wishing that I had the examination of them, for I conceived that I should have found her showing a light indeed, but such a light, and so placed, that no one could see it.

We may now ask the question, "What is a proper light?" And the better to answer this question, I have, through the kindness of Mr. Nunn—I believe the largest, as he is certainly the best, manufacturer of ship's lights in London—been able to bring together some of the best, as well as some of the ordinary lights carried by ships at sea.

Let us take the mast-head light first. The regulations state it is to be "a bright white light, so fixed as to show an uniform and unbroken light over an arc of the horizon of twenty points of the compass," that is, "from right a-head to two points abaft the beam on either side; and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least five miles."

Now I must first say most distinctly, that I have never yet seen any masthead light which fulfils this last condition. Five miles is a very much greater range for ships' lights than people are aware of, and I would give a great deal to be shown any permanent light fit for ships' use, which can be seen "*at least* five miles." The ordinary range of the best mast-head lights does not in the English Channel exceed three and a-half or four miles in the clearest weather.

It is, however, quite desirable to have a high nominal range for lights, even where it is at present unattainable, because it at least encourages makers to do the best they can towards it.

The other parts of the regulations are, however, quite attainable, but are, I am sorry to say, too often evaded, in order to receive a larger profit upon the lamps, or else to reduce their price to merchant captains who are careless of the construction of their lights.

The glasses for mast-head and bow lights are usually made by hand, in a cylindrical form, like this produced, a plan and section of which is represented in fig. 2. They are afterwards cut in the direction of the axis into the portions required to fill up the front of the lamps.

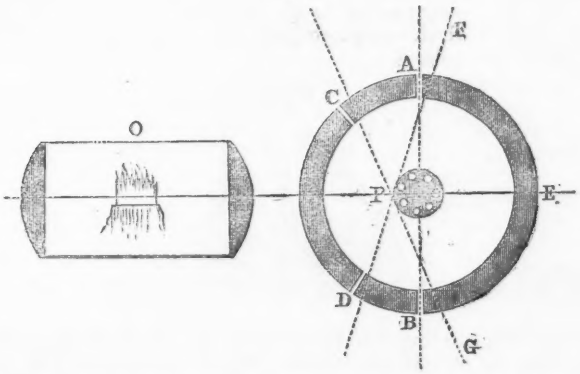
Now if I, being a lamp-maker, buy half-a-dozen of these cylinders, I can properly only make six lamps out of them, but if I am not particular as to regulation, I can make twelve, which of course will make all the difference in my profits. If I cut the cylinder in the points A and B, at the extremities of its diameter, I can make a lamp out of each part, which will fully pass muster to the uncritical eye. But when one of these lights are hoisted at the mast-head of a steamer, the full power of the light is only shown six points on each bow, instead of ten.

This may be clearly seen by a reference to the diagram.

E is the front part of the lens pointing right a-head; P the flame of the lamp; A E B the lens, which terminates at A and B. If the flame were a mathematical point, an observer very little before the beam would get the whole power of the light, but the actual size of the flame being considerable, every part of it which is hidden by the metal of the lamp is so much taken from the range. About two-thirds of the flame is hidden in this lamp from an observer a-beam, which is just as much

as to say that, supposing the light could be seen five miles a-head, it could only be seen about a mile and a half a-beam. The full range of the light, so far as the lens goes, is only shown between the lines F P and G P.

Fig. 2.



To construct a lamp according to regulation, only the piece C D should be taken out of it, and then the full power of the light is displayed over the arc from C round by E to D. But this latter cutting uses a whole cylinder, and is therefore more expensive, and the temptation of cheapness carries the day.

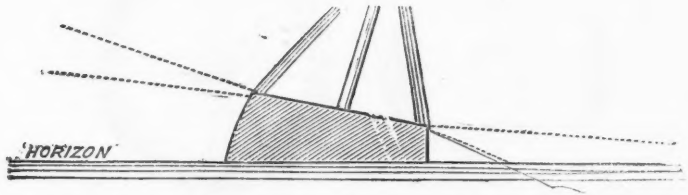
Exactly in the same way, but in a greater degree, does the snare of cheapness operate to undo the regulations regarding bow-lights. The coloured lenses are made in the same manner as the white ones, in cylinders. One cylinder will only make two bow-glasses, when the regulations are rigidly fulfilled, although the difference between this cutting and that into three equal parts is so slight that one would not be inclined to call upon manufacturers to waste very nearly one-third of each cylinder. But the inferior lamp-makers do not rest here, for in the struggle after cheapness, a single cylinder is made into four, five, and I believe even six bow lights, each never showing a full light a-beam, and reducing the arc of light till it only shows five or six points on the bow, instead of ten. What amount of good look-out will enable a man to see the bow light of a ship which is a-head of him, and steering a course across his bows, if it only illuminates an arc of six points of the compass?

Owing to the difficulty of obtaining the requisite range for ships' lights by increasing the amount or brilliancy of the flame, the usual course is to compress the rays of light by means of lenses and reflectors. Very curious ideas of optics have developed themselves in the attempts of most lamp-makers to arrive at this result, of which specimens are here before us. Mr. Nunn's lamps are the only ones I have

examined which are constructed on anything like scientific principles; and, doubtless, as he finds the subject becoming more ventillated, he will be able to make improvements which will succeed commercially, doubts as to which success are, at present, a drawback.

The effect of all lenses for ships' use should be simply to bend the rays, which would naturally proceed in an upward or downward direction, into one nearly parallel to the sea level. An objection to the practice exists, which has not yet been met. This may be understood from the diagram fig. 3.

Fig. 3.



If the ship carrying lens lights has a very small list, say only five or six degrees, observers at sea lose their full power when a few points on the bow, and may lose sight of the lights altogether at a short distance when abeam, or nearly so.

To remedy this defect, the lights should all be carefully placed on gimbols, so as to preserve their perpendicular throughout all the motions of the ship. But then, again, this would make the lamps more expensive, and the marine public are not sufficiently alive to the necessity of the case to make it worth any tradesman's while to attempt such an improvement.

When we come to the very inferior classes of lamps which are sold and used, we find that in no particular do they reach the regulations. So far from the coloured lights of this quality showing two miles, as called for by the regulations, I should think one-fourth of the distance would be an exaggeration of their range. And if we add to all these other defects bad oil, smoky and cracked glasses, leaky oil vessels, and charred wicks, all of which are the rule and not the exception—we shall get something of a clearer idea why collisions by night are three times as numerous as by day, and why a conveniently bad look-out, accounts for so many of the mishaps.

There is yet one column of the returns to be dealt with, namely, that which states thick and foggy weather to be fourth in order in the production of collisions.

For penetrating through a misty atmosphere no sufficiently powerful permanent light exists, or is likely to be produced, and here it is that I hope an extended use of Captain Bolton's and my own warning lights will reduce the number of collisions traceable to thick and foggy weather in future years.

To be able to declare your position, and the direction of your head,

in an instant of time to a ship coming down upon you in thick weather, must undoubtedly conduce to your safety at sea. And who is to say how many of these wretched casualties, such as occurred off the Start the other night—where a steamer runs down and sinks a schooner with all hands, in a period just long enough to see it *was* a schooner, and to hear a few drowning cries—would be avoided, were ships in the habit of carrying on deck and at hand, boxes of such powerful lights, ready to be used at any juncture, and requiring no skill and almost no thought in their management.

It is our usual course here, I observe, not to close a paper pointing out defects in materiel or administration without suggesting a remedy, if only to furnish a basis for discussion and the expression of opinion.

The "warning lights" form in themselves one suggested improvement, and as I hear nothing but encouraging accounts of them, and as they have been already taken up by one or two large Companies, I am disposed to hope this remedy will in course of time apply itself.

As regards the present defective construction of the majority of lights carried by ships at sea, I think it would be stopped, and their whole management improved, if the Board of Trade were to provide pattern lamps according to regulation, and place them in the hands of their officials at all the out-ports, to be exposed in the shipping offices or other place of resort for merchant captains. These latter might then be expected to learn more of the differences between proper and improper lights, and it would become more difficult to make sales of those which were not according to regulation. And then again, when collision inquiries arose, which turned on the light question, the pattern lamps would be brought forward to condemn the guilty and exonerate the innocent.

But there is one improvement I should like to see in ships' lamps which is not touched on in any of the regulations yet. I mean the substitution of candles of a selected pattern, for oil. Although no candles suitable for merchant ships have yet been manufactured which will give a better light than the six or seven wicks of oil usually fitted in the best lamps when first lighted, yet as the flame from the oil wick constantly deteriorates from the moment of lighting, while the candle flame does not do so, a candle will have given out, during four hours, a greater amount of light than oil. Candles also are open to none of the objections to oil. They are cleaner, and much less troublesome to manage; the glasses and reflectors of candle lamps do not become so clogged as those of oil. And lastly, by establishing a pattern candle as well as a pattern lamp, you get a much greater certainty with regard to the quality of light displayed by ships.

The CHAIRMAN: Perhaps Mr. Gray will be kind enough to favour us with some remarks?

Mr. GRAY, Board of Trade: I have listened to the paper of Captain Colomb with very great attention and with much pleasure, and I may say at once, that from his remarks he has evidently paid great attention to the subject; but I think he is a little hard upon the Admiralty Courts in their decisions. They have the facts of the case before them; they have competent assessors to advise them; and I think that the calm, deliberate judgments at which they arrive after maturely considering the facts

of the case, and after hearing the evidence, are very likely to be right; and if their decision is that a casualty did happen through a bad look out, we may safely conclude that such was the case. As regards the Board of Trade wreck returns, I think they are quite open to the question that Captain Colomb would raise. They are not, and never can be, accurate and indisputable classifications of causes of all wrecks, but are intended to be merely as far as the evidence goes, approximate Tables of Causes. Captain Colomb asked how we knew a collision was caused by a bad look out? how we knew it was caused by neglect of the rule of the road? how we knew it was caused by improper lights? I will tell you. Whenever a collision happens on the coast, whether it goes into the Admiralty Court or not, the case is investigated by the officer of the Coast Guard on the spot; by an officer capable of forming an opinion upon the points likely to come under his consideration, and capable of making a report when he has formed an opinion. I will give you an instance of what may be put down as neglect of the rule of the road, and what as a bad look out. I can tell you of cases where several ships have been anchored together in a much frequented roadstead, where not a soul has been on deck, and those below have only known that they were in collision when they have been bumped out of their berths, or have found themselves in the water. That, I take it, is an exaggerated case of bad look out. There are many cases equally palpable. But there are many cases in which ships are under way in which great difficulty arises; and if you look at the Returns, you will find that the headings are not put in a peremptory or exclusive manner. There is one remark that Captain Colomb has made from which I most strongly differ, in which he says that the Board of Trade ought to find pattern lamps and pattern candles. Now, the Board of Trade are not lamp-makers, nor are they candle-makers, and I think that the officers of the Board of Trade would strongly object to their having anything to do with selecting or appointing people to select pattern lamps or pattern candles, supposing they could do it. But can they do it? In the first place, when you select the lamp and say, "that shall be the lamp that shall be used," at once you put a bar to all improvement. Supposing that, in what we considered our enlightened state, in 1862, when the naval officers of the Board of Trade and the Admiralty, in connection with the naval officers of the Emperor of the French, made the present regulations for preventing collisions at sea—supposing that at that time we had said that a lamp of a certain pattern shall be the lamp adopted in all cases—had we fixed on a pattern then, we should not be able to use some of these lamps now, shown to us by Captain Colomb, which are very much better, because the pattern lamp which had been adopted would have prevented their being used. Again, suppose two steam-ships, one carrying a pattern light adopted by the Board of Trade, the other carrying the ordinary, or perhaps not pattern lights, but lights equally as good as the other; supposing those two ships came into collision, then, according to Captain Colomb's rule, as I understand it, the one that had not the pattern lights would be the one in fault. As the lights themselves really form a very small portion of the requirements for preventing collisions, that would be hard, and it would be wrong. Supposing the lights that were made according to pattern were not properly trimmed, supposing the glasses were cracked, or were smoked; and supposing, on the other hand, the glasses of the common old lights were good, and the lights themselves in order, then it would be very wrong to attempt to throw the blame on the vessel which had not the pattern lights, when her lights were better than the others. It would be, in fact, going back to that system of "meddling and muddling," which the Government are trying to undo now, as much as some years ago they were trying to retain. As regards the lamps of the "Samphire" and the "Fanny Buck," Captain Colomb asked if those lamps were produced in Court. They were produced in Court; they were placed before the Surveyor of the Board of Trade; he was asked his opinion on them, and he said, in effect, that he would not pass them for any vessel in the United Kingdom. The green lamp has been stated to have been made of a dirty bottle-green that could not be seen at the distance of two miles and a half.

Rear-Admiral Sir F. NICOLSON: Was that in the Admiralty Court, or in the first investigation?

Mr. GRAY: Here at Westminster. I have no more to say, except to urge upon you all, by no means to advocate Government interference in matters of detail.

Commander DAWSON, R.N.: I think it is a subject of regret that we have so small a meeting to-night. Perhaps it may be accounted for by the fact that the subject being a naval subject, we lose one-half of the audience on these occasions; our military friends not coming forward in their usual strength. Otherwise, I think it is a subject of great importance to those connected with naval matters, and one which, perhaps, no one is better qualified to treat than Captain Colomb. He has devoted seven or eight years to the investigation of this subject, not only in the laboratory, but he has actually carried out a long series of experiments in the Channel fleet; therefore he can speak with a certain amount of experience, which very few naval officers have, upon that point. Therefore, what he has said is well worthy of being discussed. With reference to Mr. Gray's reply as to the conduct of the Board of Trade in their management of matters connected with the Merchant Navy, I do not think the Merchant Navy, as far as the safety of the seamen is concerned, have to thank the Board of Trade for much. The Board of Trade do not look very much after matters connected with the comfort of the seamen, or with many of the things that bear upon the safety of their lives. To me it is no matter of surprise that improper lights should be carried on board our merchant ships; many of them leave our ports in a state with regard to many equally vital points that is disgraceful to this country. There was one portion of the subject which I came here to listen to to-night that I hoped to have heard a little more about, and that is with reference to our own navy. Mr. Nunn has devoted a great deal of attention to the subject of supplying the navy with good lanterns; he has gone to considerable expense, and has supplied us certainly with very good lanterns, the best we have had hitherto. But there is one suggestion Captain Colomb has made which is worthy of attention, that we really want some better lights. Notwithstanding that we have got the best heretofore out, we want something better, because in the Royal Navy the trimming of these lights is a serious consideration. They are left one night to the captain of the foretop of one watch, and the next night perhaps to the captain of the foretop of the other watch. The captain of the foretop may know all the duties of the foretop yet have very little knowledge of a ship's lights? The consequence is that the lights are very badly trimmed and badly taken care of; and though there is what is called a lamp-trimmer in Her Majesty's ships, yet his education and knowledge seldom go further than how to clean the brass of the lamp. A light, which may be very good in the first watch, will be found towards twelve o'clock, or in the middle watch, to be getting very dim indeed. Mr. Nunn was on one occasion complained to by the captain of a ship of war as to the bad light given out by his lamp. Mr. Nunn asked permission to see the lamp: it was shown to him, and he found it was covered inside with grease and oil, and the wick, and arrangements inside, were in such a condition that it was impossible for the lamp to give a proper light. I really believe that that very often occurs on board Her Majesty's ships, how much more often, then, must it occur on board merchant ships, where there is no midshipman to go round every half hour to see that these men do their duties. I think it would be a good thing to get rid of the oil altogether, and replace it with candles. Mr. Nunn has also given a great deal of attention to that point, as well as Captain Colomb, in the endeavour to discover a candle which will carry a number of wicks, so as to give a good light. It has not proved an easy problem to solve, but it is one which I think is deserving of great attention—to get better lights if possible, and to use them to the best advantage when we have got them.

Mr. HARPER: I understood Captain Colomb to propose that the Board of Trade should have a lamp, which should not be authoritatively issued by the Board of Trade as a lamp to be used necessarily by all persons, and the non-usage of which should, in a case of trial for collision, at once condemn the ship; but that the Board of Trade should have a model lamp made, which model lamp should be a standard lamp, a lamp of reference, so that the tradesmen who are manufacturing

lamps without any knowledge at all, and the shipowners who are using them without any care whether their lamps are effective or not, should have before them a model lamp, and the public should be able to have one always to refer to—a model lamp efficiently constructed, and examined by the Board of Trade, whose function, it seems to me, is especially to interfere in such cases, and who are not to be supposed to drop their hands in the face of such difficulties as those of lamps, because it is interfering with private enterprise. It would be, it seems to me, specially within the functions of the Board of Trade.

Mr. GRAY: Under what Act of Parliament?

Mr. HARPER: Under general principles. The Board of Trade makes Acts of Parliament for all these cases, and bases those Acts upon broad general principles. The broad general principle has been announced by Mr. Gray to-night, that the "meddling" of the Board of Trade is "muddling." Now, all Government is meddling; Government means meddling. If Mr. Gray is prepared to say that the Board of Trade never meddles without muddling, well and good! We must not look to them for any alteration in the matter of lamps; we cannot think of applying to them to make a standard lamp. But I imagine Captain Colomb simply meant, not that the Board of Trade should issue a definite kind of lamp which was to be used necessarily by all ships, but that they should issue a standard lamp, so that persons who wished it, should know whether tradesmen were supplying them with proper lamps; or that persons who were going to send goods abroad and entrust them in a ship, if they thought the question of lamps an important one, might refer to that standard lamp, and might see whether their property was sufficiently protected in this respect.

Mr. GRAY: Would you have model anchors and cables as well?

The CHAIRMAN: The question is that of ships' lights, and I must ask you to confine the discussion to that question.

Captain LEOPOLD HEATH, R.N., C.B.: It is a very important question that has been raised. The Government have decreed that ships shall carry certain lights; and I think it is quite open to argument that the Government should define what those lights should be.

Rear-Admiral A. P. RYDER: The question has been raised by Captain Colomb with reference to the nature of the oil consumed. Now, sperm oil is used invariably by the Admiralty for the side lights of ships at sea. I had the opportunity a few months ago, when I had charge of the Coast Guard, of instituting some experiments on the relative value of sperm and colza oil for the purpose of side-lights. The experiments were all in favour, at the first start, of the colza oil. But, on reference to the Victualling Department, I was informed that if sperm oil was put in iron casks, as it always had been, or, if it was put into another cask in which there was a rusty nail, the sperm oil was materially injured; and that they had therefore lately adopted the plan of sending it to sea in casks made of some other material than iron, and they hoped that the oil would retain its character. After this, I had the opportunity of instituting other experiments with the sperm oil, which was kept in the improved casks, and the result of these experiments surprised me. I think the different officers of the eleven ships that carried on the experiments during the winter were perhaps equally divided as to the relative merits of the colza and sperm oil. But the expense of the oils is as one to two; the colza is only half the expense of the sperm. There seems not to be much difference, so far as we could make out, as to the relative brightness given out by the two oils. There is one point about the rays which Captain Colomb spoke of. I do not think he alluded to the reflectors in the interior part of the lamp.

Captain COLOMB: I did not mention them.

Admiral RYDER: The reflectors in Mr. Nunn's lights are always metallic, which apparently after a little time lose their power of reflection. The reflector becomes rough from being polished with sandstone, and very soon ceases to be a perfect reflector. In fact, I have seen a reflector painted; this, of course, has prevented its sending forth any rays at all. Mr. Stephenson, the great lighthouse designer and constructor in Scotland, is trying to get a perfect reflection from ship's lights, by means of glass prisms, which could be easily cleaned with a sponge, and there-

fore require no rubbing or polishing. He has put one on the Scotch Lighthouse yacht, and he hopes to get a very good result. He says he can construct it very economically indeed. In that case you would save all that lost angle of light, and you would throw out rays, as you do from a reflector now to a certain extent, only you would send them by total reflection, by means of prisms. I believe the green and red lights are now of the same size, whereas it is notorious that the green light is not seen so soon as the red. If you wish the red and green to be seen at the same time from a ship a-head, the green light ought to be more powerful to bring it up in intensity to the red. When I was a member of the Lighthouse Commission, I looked into the question of colours, and I found the green stood very low indeed in the scale. It occurred to me, what objection could there be to having a white light instead of a green light? At all events, the green light should be made as good as possible, and be brought up to the standard of the red light, which can only be done by having the lamp for the green light half as large again as the lamp for the red light.

Captain COLOMB: I quite agree with most that Admiral Ryder has said; but I do not think it would be possible by any system of reflectors to use them in the same way that lenses are—that is to say, to catch the back rays and throw them out again. You would increase the power of the light as far as they are reflected, but unless you did away with the lens altogether, you would still have the effect I have shown there; you would have a brighter light by the combination of the lens and the reflector, which we have here. By the combination of the lens and reflector we get a brighter light throughout the whole disc of light; but the objection to a fixed light remains just as strong as ever: that is to say, the lens bends the rays, and the reflector must also bend them to give you any extraordinary power of light; and the rays being bent out of one place and into another, the lamp must be allowed to move to keep the rays in the direction in which you want them to travel. As to colza oil, I believe it is most commonly used in merchant ships. Mr. Nunn has found exactly the same result that Admiral Ryder did: that it is very much better, and requires less trimming, and is more suitable altogether for ships' lights than sperm oil. I should like to ask one question of Mr. Gray. He has mentioned a certain class of cases, which he says is put under the column of "neglect or misapplication of steering rules." If the cases he has mentioned come under "misapplication of steering rules," what class of cases comes under "general neglect and want of caution?"

Mr. GRAY: If you will only be good enough to call at my office to-morrow, I will show you with great pleasure.

Captain COLOMB: I only wished to ask the question.

The CHAIRMAN: We are very much obliged to Captain Colomb for the paper which he has been good enough to read to us, and also to the gentlemen who have made their remarks upon it. I conceive that we gain very much by these discussions. One gentleman has remarked about the smallness of our audience. I attribute it not only to the fact that it is a naval question, and, therefore, more exclusively belonging to the naval profession; but also to another fact, namely, that a very large proportion of our members trust to reading the reports of our meetings, and if there were only a dozen people here, there are a great many who read the reports and profit by them as much as if they were present. At any rate, we must not restrict in our imaginations the usefulness of these meetings by the number of persons who happen to be present. With respect to the question between Captain Colomb and Mr. Gray, of the Board of Trade, there is a good deal to be said on both sides, and where there is a good deal of truth on each side, I think we may gain something from each. In the first place, it would be a very bad thing if any fixed standard for these lights were made, because it is always the tendency of authority, whatever it may be, to regulate everything for a number of years, and thereby to shut out improvements which might be called innovations. That would never do. At the same time, on the other hand, we must remember that those who are entrusted by the community with the power of making these regulations, might very reasonably be called upon by public opinion to go one step further, and see that those regulations are exactly complied with. Certainly, looking at some

of these lights before us, these specimens of imitations, I think we may fairly say that the regulations made by the Board of Trade by the authority of the country, are not complied with. There are certain rules laid down; surely somebody should be responsible for those rules being carried into effect. I think in all cases of official inquiry, whether before a court of law or whether before the constituted authorities who have to inquire into them, we might have the question looked into, as to whether these wholesome regulations made by the Board of Trade are virtually carried out, not in words, but in fact, so that the opposing ships might either be considered innocent or guilty according to the law laid down by the authorities. Another question is the question of candles. Decidedly, the better light is that given by an oil lamp, if it is well trimmed, and attended to, and has plenty of air. I agree in the advisability of having a light which will be continuous, which will be the same light throughout, and which will not require so much trimming and so much watchfulness on the part of those who, unfortunately, are often deficient in the common-sense necessary to keep those lights in order. Therefore, I think candles, if we could get them good, would answer better. But there is a good deal also in the question of keeping candles on board ship, whether they would deteriorate by long keeping or not? I, myself, know that such things do sometimes deteriorate by keeping, and do not give a good light, and that, whereas, at first they would be good for ships' lights, their illuminating powers would so far fall off that you could not trust them at all. Therefore, we must not too quickly adopt candles without experiments. Another point was that of lamps delivering their rays always horizontally. The only way to do that is to gimbol the whole lamp with its glass-covering; and we must take care that it is done from the inside, so that the stroke of the sea, when it comes up the ship's side, shall not come across the gimbol at all. If we can manage that we shall do well. I do not know that there is any other point that I need mention. With respect to figure 2, it speaks for itself. But I think we might fairly ask the constituted authorities to condemn any ship of any size, man-of-war or merchant ship, that did not carry out the regulations regarding the proper size and the proper periphery of the lens. We might ask for that. Be the ship large or small, it is only having a larger or smaller lens. But the principle is the same, and the principle should be carried out. I have now only to thank the gentlemen who have spoken, for their opinions, and for the information they have given us, and especially to thank Captain Colomb for the paper he has read.

A FEW REMARKS ON THE "RULE OF THE ROAD," AND SUGGESTIONS FOR ITS AMENDMENT.

By Captain Charles Curme, R.N.

Having been kindly granted permission, I wish to make a few remarks on what we sailors call the "rule of the road," and to offer one or two suggestions for its amendment in particulars which I think urgently demand it. I must, in deference to you and justice to myself, observe that I do not for a moment suppose that I am going to say anything new on the subject, for I am fully aware that it has occupied the earnest attention of many men more fitted and able than myself to deal with it; but it is a branch of our profession that I have always been attentive to, and have lately been called upon to go closely into. I think the discussions of the last two meetings have plainly shewn that we are all agreed as to the great value of any system of lights that would enable a ship at night to ascertain not only the *position* of another ship she may be meeting, but the course that ship is steering, her own being indicated in the same manner; but I am sure you will agree with me that the most accurate knowledge of their mutual courses will be of little value to the officers in charge of the navigation of those ships, unless they are furnished with a clear, distinct, and generally applicable rule of the road.

Undoubtedly the principle that should govern the movements of two ships meeting, should be the keeping or getting out of each other's way by the shortest and most expeditious route—in the case of an impending collision every *second* of time *saved* being of the utmost importance. Now in the case of ships meeting each other "end on"—*i.e.*, all masts in one, or shewing each other *both* side lights, or "crossing" each other under such conditions as to make it indifferent in point of time which side they should pass each other on, or which ship should give way to the other—it is manifest that an arbitrary and conventional rule is necessary, and this is furnished by the regulations, which provide that in the one case *the ship which has the other on her own starboard side shall give way to the other; and in the other, that the helms of both shall be put to port, so that each ship may pass on the port side of the other.* So far so good. But when we come to cases under other conditions, I venture to assert, that on investigation it will be found that in many instances collisions have been caused by the officer in charge of one of the meeting ships, without the least reference to the particular circumstances of the case, putting his helm to port, and comforting himself with the reflection that, as he was obeying the

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Undoubtedly the principle that should govern the movements of two ships meeting, should be the keeping or getting out of each other's way by the shortest and most expeditious route—in the case of an impending collision every *second* of time *saved* being of the utmost importance. Now in the case of ships meeting each other "end on"—*i.e.*, all masts in one, or shewing each other *both* side lights, or "crossing" each other under such conditions as to make it indifferent in point of time which side they should pass each other on, or which ship should give way to the other—it is manifest that an arbitrary and conventional rule is necessary, and this is furnished by the regulations, which provide that in the one case *the ship which has the other on her own starboard side shall give way to the other; and in the other, that the helms of both shall be put to port, so that each ship may pass on the port side of the other.* So far so good. But when we come to cases under other conditions, I venture to assert, that on investigation it will be found that in many instances collisions have been caused by the officer in charge of one of the meeting ships, without the least reference to the particular circumstances of the case, putting his helm to port, and comforting himself with the reflection that, as he was obeying the

"written law," so he was placing himself beyond the reach of blame, happen what might; for be it observed that Article 14, while directing which ship is to give way, makes no mention of how it is to be done, and I know that the opinion has been, and still is, widely prevalent, that it *must* be done by *porting* the helm; it can easily be shewn that in some cases such a course would be a dangerous, and in many others a long and circuitous one. The officer of the other ship takes what perhaps I may be allowed to call the "common sense" view of the case, puts his helm to *starboard*, or, it may be, holds on, and the consequences are such as are unfortunately too familiar to us all. Cases can be given in which ships have sighted each other at a distance of several miles, but by perseverance in a course similar to the foregoing, have succeeded in running foul of each other.

As it stands first, I will, however, return to the Article governing the case of ships "meeting," as it is called (Article 13), and in it I object to the use of the expression "*nearly* end on," as vague and indefinite, and, as may be easily proved, productive of much dangerous doubt and misconception. I propose that Article 13 shall run thus:—"If two ships under steam are meeting *end on—i.e.*, so as to show "each other all masts in one or *both* side lights—the helms of both "shall be put to *port*, so that each may pass on the port side of the "other." It will be observed that this applies only to the case of ships meeting each other in exactly opposite courses.

Again, in Article 14, which provides for the case of ships under steam "crossing," it is laid down that "the ship which has the other on her "own starboard side shall give way to the other," but does not direct how it is to be done. Now no doubt it will be said at once, "any "*sailor* will see at a glance how it is to be done, and there is not the "slightest occasion for any written rule on the point;" but I assert, and can bring ample proof in support, that it is often attempted in the wrong way, and not only that, but on reading the reports of cases of collisions that have been tried, it will be found that a ship *putting her helm to starboard*, has in some cases been held to be in the *right*, and in others, under apparently precisely similar conditions, has been held to be *wrong*, for not *porting* her helm "according to the statute," and I am convinced that, clear as the cases in which the *starboard* helm is *necessary* and *proper*, may appear to you, or to any men thoroughly up to their work, there are a very large number of men for whom a clear imperative direction is required, and I venture to suggest that Article 14 should stand as follows:—"If two ships under steam are approaching "each other in any other direction, so as to involve risk of collision, the "ship which has the other on her own starboard hand shall give way to "the other, which she shall do by putting her helm to *port*, if she has "not reached the other's line of keel and sees her *red* side light only, "but by putting her helm to starboard if she is *on* the other ship's line "of keel and sees *both* the other ship's side lights, or has *crossed* her line "of keel and sees her *green* side light only." For the convenience and ready reference of captains and officers in charge of the navigation of ships, I propose that a table such as that given hereafter, showing all the different conditions under which ships may meet, with risk of colli-

sion, should be placed near the bridge and wheel, and to facilitate the use of it, the look-out-men should be instructed to make their reports in one regular form, thus :—"Green light right a-head; red and green "light on starboard bow; red light on port bow;" and so on, the officer in charge at a glance at the table, sees at once what is to be done.

I wish to say a few words more about the expression "*nearly* end on." I have consulted with several of the most experienced officers I know, and all are agreed that it is dangerously indefinite, and indeed can only be stated arbitrarily to mean, a direction not differing more than a point or two from an exactly opposite course. Under the present system of lighting, it is evident that we are utterly unable to ascertain this at night; a system such as the excellent one proposed by Captain Heathcote, would enable us to do so with a great degree of accuracy, but as things are, and as the regulations are at present worded, it is evident that an officer is left in doubt as to whether he is to obey the rule for meeting or crossing; I venture to say that the wording I have suggested for the Articles 13 and 14 does away with the uncertainty; the relative position of the masts in the day-time, and the seeing particular side-lights at night, will give unmistakable indications as to which rule should be followed. I will not take up more of your time by quoting any particular cases, but several may be found which clearly illustrate what I have said as to the misconception and consequent wrong-doing which appear to result from the present regulations, of which I should say that they clearly recognise and admit the necessity of legislation, but do not carry it sufficiently far. It is for your consideration whether what I suggest goes far enough without being impracticably and mischievously minute. Since I first took up this subject I have obtained a pamphlet published in 1857—but who the author is I do not know—which contains a letter from the Admiralty, dated December 11th, 1854, addressed to Messrs. G. McTear and Co., of the Steam Packet Office, at Belfast, and as it bears directly on our present subject, and is moreover strongly confirmatory of my own views, I will quote it, observing that in paragraph 2 of Messrs. McTear's statement, a small alteration is necessary in detail but not in principle, in consequence of the regulation pointing out which ship of two crossing is to give way, being of a date long subsequent to that correspondence.

Correspondence between Messrs. McTear, of Belfast, and the Admiralty on the subject of the Instructions relating to Steamers' Lights.

Messrs. McTear say:—

"Supposing two steamers from nearly opposite points of the com-
" pass to be approaching each other *with the masthead and green lights*
" ONLY of each visible from the other, we wish to know what should be
" done; should each continue her course, or rather put the helm a
" little to starboard than otherwise, or should each port and cross the
" bows of the other?

"On the other hand, supposing *the masthead and red lights* ONLY of "each visible from the other, should each continue her course; or, if "anything, *port* a little, not starboard?

"There is an opinion prevalent amongst captains, that, when two "steamers are meeting one another, the helms of both should be "PORTED, *without reference to what lights are visible from each;* but, as "there are some who think otherwise, we feel anxious to know which "is correct, and shall be glad to have your opinion on the subject.

"1. The interpretation of the latter is,—that, in the first situation, "as shown by your diagrams, where A sees only the mast-head and red "lights of B, but B sees all the lights of A, each vessel should port "her helm; or, B continuing her course, A should certainly *port*, and "pass astern of B.

*"2. That, in the second situation, where A sees B's mast-head and "green lights only, but B sees A's three lights, each vessel should "starboard her helm; or, B continuing her course, A should starboard, "and pass astern of B.

"3. That, in the third situation, where A and B see but each other's "masthead and red lights, they should continue their respective "courses; or, if any change be made in the helm, it should be in the "PORT direction.

"4. That in the fourth situation, where A and B see but each other's "mast-head and green lights, they should continue their respective "courses; or, if any change be made in the helm, it should be in the "*starboard* direction; and lastly,

"5. That, in the fifth situation, where A and B see all the lights of "each, the helm should be *ported* in both.

"We shall feel obliged by your informing us, at your earliest con- "venience, if the interpretation herein given be correct; or, if not, "what is the proper explanation of the diagrams."

The following is the reply of the Admiralty:—

"Admiralty, Dec. 11th, 1854.

"Gentlemen,—Referring to your letter of the 17th ult., upon the "subject of the interpretation of the Circular, No. 107, relative to "lights to prevent collision, I am commanded by my Lords Commis- "sioners of the Admiralty to acquaint you that the opinion which you "allege obtains among masters of steam vessels, that when two "steamers meet one another, the helm of *both* is to be ported, without "reference to which lights are visible from either vessel, is erroneous, "and founded upon a misconception; indeed, their Lordships are of "opinion that such a course would not only be a violation of the esta- "blished regulations, but might lead to very disastrous consequences.

"In conclusion, I am commanded to acquaint you that the interpre- "tation given in your letter of the several diagrams illustrative of the

* As according to the latest regulations "the ship having the other on her own starboard side is to give way to the other," this should be substituted—"or A continuing her course, B should starboard and pass astern of A." It will be observed that this does not affect the principle of the use of the *starboard* helm in certain cases.—C.C.

" established regulations which is opposed to the misconception is " perfectly correct.

" I am, Gentlemen,
" Your obedient servant,
(Signed) " A. MILNE."

" Messrs. G. McTear and Co.,
" Steam Packet Office, Belfast."

Thus it appears that the interpretations in the paragraphs which are marked 1 to 5 contain a correct view of the intended regulations.

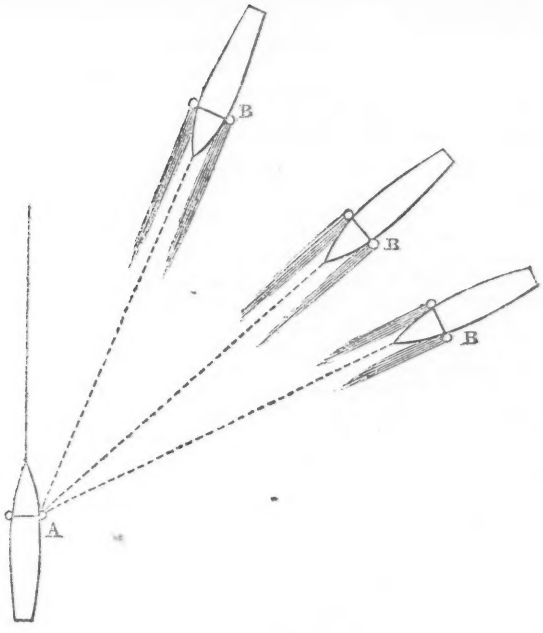
The diagrams they refer to are to be found, I believe, in any of the copies of the " Regulations for Preventing Collisions at Sea," issued by the Board of Trade. I particularly wish to point out to you that although this correspondence so clearly establishes the fact of the existence of the misconception on the subject of the obligatory use of the port-helm on all occasions, and their Lordships so strongly express their disapproval of *that* interpretation, and their concurrence with the one set forth by Messrs. McTear and Co., yet, so far as I am aware, that approval has never been made generally known, and I am asking for nothing more now than that the principle therein recognised, shall be put in a clear, imperative form, so that in case of collision there may at all events be less than the present difficulty in deciding who shall bear the burden and penalty of wrong-doing, and that the hesitating, and, perhaps, inexperienced, may be relieved from much anxious and painful indecision.

In conclusion and explanation of the table, I should like to observe that although it is intended to include all the cases in which collision is possible, they all may be reduced under the two heads of ships *meeting each other* " *end on*," when each *ports* her helm; and *meeting each other in any other direction, so that there is risk of collision*, for which case we need only establish the mode of giving way to be followed by the ship having the other on *her own starboard* side—the other ship will of course have her opponent—if I may so call her—either *on her port side*, in which case she should keep her course, or *a-head*, when she should put her helm to *port*, if she sees the *red* side light only, but to *starboard* if she sees the *green* side light only.

The following diagrams illustrate cases in which it is proposed that it shall be *declared* obligatory to put the helm to starboard.

Case I.

In any one of the three positions of B shown in the diagram, A sees both B's side lights on his *starboard* bow or side. B sees A's *green* side light only, *right a-head*. A must give way by putting his helm to *starboard*. B would probably go clear if he kept his course, but as a matter of precaution, *he should put his helm to starboard also.*



Case II.

In this case A and B see each other's *green* side lights only, and it is evident that if they *both* keep their courses they would go clear of each other, but as in supposed compliance with the statute, it is too often the practice for *one* or *both* to *port* their helms, or still worse for one to *starboard* and the other to *port*, it is suggested that it be made obligatory that, one *green* side light only being seen, the helms of *both* ships shall be put to *starboard*.

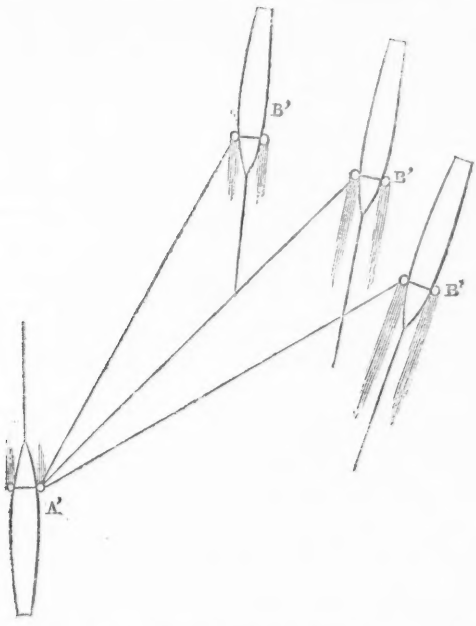


Table for the use of captain and officers in charge of watches, shewing the course to be pursued on sighting a steamer's lights.

Bearing and description of lights.	*Evolutions to be performed.*
Red and green lights *right a-head.*	*Port* the helm.
Red light *right a-head.*	*Port* the helm.
Green light *right a-head.*	*Starboard* the helm.
Red and green light on *starboard bow.*	*Starboard* the helm.
Red light on *starboard bow.*	*Port* the helm.
Green light on *starboard bow.*	*Starboard* the helm.

(In the last case ships ought not to go near each other without touching the helm, but it is safer to put it to starboard,)

Red and green light on *port bow.* Red light on *port bow.* Green light on *port bow.*	* Keep your course.

* N.B.—Mind your ***port helm*** and keep or get the lights ***broad*** on your *port* bow.—C.C.

In conclusion, my proposals are to do away with the expression "nearly end on" in Article 13, introducing a definition of "end on;" —to supplement Article 14 by directions how the giving way is to be performed (in other words, to declare when starboard helm *may* and *ought* to be used); and the giving to officers in charge of ships, a table, which, with the proper instruction to the look-out men, will, I think, materially assist them in doing the "right thing at the right time." As I understood the subject for to-night was "the safe navigation of steam-ships by night," I have not touched upon the articles applying to *sailing* ships, and I am not prepared to say that it is requisite, but I anticipate little difficulty will be found in framing rules for their government upon the same principles, should it be thought necessary. I trust that, even if my propositions are disapproved of, either as unnecessary or bad in form, that at least what I have said will have the effect, by producing discussion, of calling forth from the proper authorities some such clear expression of opinion as that I have referred to as having been given in the Admiralty letter of December 11th, 1854.

Captain HEATH, R.N., C.B.: I take it that no two ships, seeing only green lights, would ever put their helms a-port.

Captain CURME: But let us come to the case of two ships meeting "end on, or nearly end on," as they call it. We will suppose B is slightly inclined—at night we cannot tell how much. A in this case sees both the side lights. Are they meeting, or are they nearly end on?

Mr. GRAY: They would not involve risk of collision by proceeding straight.

Mr. HARPER: What is the legal definition, under Article XIII, of coming end on?

Captain CURME: There is no definition.

Mr. HARPER: What is "coming end on?"

Captain CURME: When both side lights are seen; when both ships see each other's side lights.

Mr. HARPER: Then, when coming nearly end on, they can only see one side-light.

Captain CURME: One side-light certainly. If they see both, they are clearly both end on. This ship here first of all shows both her lights; she turns in this way; and the moment she passes from that position, she shows one light only. But you cannot tell how far she has gone round, and you may be treating it as a case of nearly end on, whereas, instead of that, she is crossing.

Captain HEATH: Might I ask you to draw the ship A so that the red light is seen by B—the case of a ship that sees the other on her port bow. The point I want to put is—that if a ship lay in the direction of A, your rule would say that as she sights B on her starboard side, she must give way. Now, the other ship ought, by the same rule, to put her helm a-port; but I do not think your rule says so.

Captain CURME: It would only be adding to the regulations. It is a case that does not very often occur. But if this ship is ever so little round, showing her green light, she would have to give way; but in this case A sees both B's lights. I put a note in, that a ship having another on her port side, is entitled to hold on; and if she does anything she is entitled to put her helm a-port, so as to ensure her red light being seen.

Rear-Admiral Sir F. NICOLSON, C.B.: If a ship is in the position of A, you say, she must put her helm a-starboard. Now, supposing B puts his helm a-port.

Captain CURME: B has no business to do so, because he sees a-head of him a green light; and by my rule he puts his helm a-starboard.

Sir F. NICOLSON: It is an understood thing by your rule that he puts his helm a-starboard?

Captain CURME: That is what is clear to me, if these rules are carried out, that seeing a red light is the signal to put the helm a-port, and seeing a green light is a signal to put the helm a-starboard. With any system like that proposed by Captain Colomb the light does two things: it distinctly shows what you are doing yourself, and shows the other ship what she ought to do; and in carrying out that system you will find that no mistake can possibly happen.

Commander HEATHCOTE: Will Captain Curme read the rule again?

Captain CURME: "A ship seeing a-head of her a green side light, is to put her helm a-starboard." That is, B sees a-head of her a green side light, and therefore has to put her helm a-starboard.

Captain HEATH: Why not add to that, "a ship seeing a-head of her a red side light shall put her helm a-port?"

Captain CURME: I have arranged it in this way: a ship seeing a-head both side lights, what is she to do? She carries out the arbitrary rule that says "put her helm a-port." The next case is, a ship seeing a-head of her a red side light—that is, a ship turning sufficient to show a red side light—she shall port her helm. Then, if a ship sees a-head of her a green side light, she is to starboard her helm. Then, here is the other case, if a ship sees on her starboard bow two side lights, then she has to put her helm a-starboard. Of course the correlative case to that is, a ship seeing a-head of her another ship's green side light, they both put their helms a-starboard. The third case is, a ship on her own starboard bow sees another ship's green side light, then there is no question that they are both to put their helms a-starboard. Under the present interpretation of the rule they would both put their helms a-port, and would go miles out of their way by doing so. But by the proposed rule, a ship seeing on her starboard bow a green side light, would put her helm a-starboard. (Captain Curme then read the letter written from Belfast to the Admiralty, and given in his paper.)

Mr. STIRLING LACON: What is the answer?

Captain CURME read the answer given in his paper.

Mr. LACON: That was written in May 1854, and still there has been no alteration of the rule?

Captain CURME: The only alteration made, is that it is now laid down that the ship which has the other on her starboard side shall give way. But this answer has never been published. To several to whom I have referred the case, I have put the question in this way: a ship showing her green light to another and seeing the other's green light, what would she do? They have said, why no man in his senses would put his helm to port. But there are numerous cases where it is done, because many seamen have got that one idea in their heads, that whatever lights are made out they must port their helm directly.

The CHAIRMAN: That is not according to the rules?

Captain CURME: It is according to the rules.

Admiral RYDER: It is not according to that Admiralty letter which has never been made public.

Mr. LACON: It is according to the rules.

Admiral RYDER: The Admiralty Regulations say not a word about starboarding the helm, not a word. The new regulations, issued a few years since, prescribe most imperatively "*porting*" the helm under certain circumstances in the case of steamers, viz., when two steamers are "*meeting end on, or nearly end on*;" but they prescribe as imperatively that when two steamers are "crossing with risk of collision," *the steamer which* "*has the other steamer on her starboard side is to give way*," and vice versâ; but "*giving way*" may, of course, be effected by *porting* or by *starboarding*, and the adoption of one of these courses may be very dangerous, and of the other perfectly safe; the mode of "giving way" has, therefore, been left hitherto entirely to the judgment of the captain of the ship that is enjoined to give way by the above regulations.

Mr. GRAY: Suppose the two ships approaching nearly end on, and each showing the other the green light, would those ships run the risk of collision if they were to continue to hold their course?

Captain CURME: Certainly not.

Mr. GRAY: Then the rule does not apply?

Captain CURME: But putting the helms a-starboard turns them more away from each other.

Mr. GRAY: But if each sees the other's green light, and if the course on which they are proceeding will carry them clear of each other, then the rule does not apply, because the rule says "if they are approaching nearly end on, so as to incur risk of collision."

Captain CURME: Who is to form a judgment?

Mr. GRAY: The people on board, of course.

Captain CURME: But we must make rules for stupid people—for wrong-headed people.

A MEMBER: Your rule is, if you see a green light you starboard your helm; if you see a red light you port your helm?

Captain CURME: Yes.

Mr. LACON: Surely, such a rule as proposed by Captain Curme would be understood by the most ignorant man. Legislation should be, not for the intelligent captain only, but for the half-instructed man, who has honestly puzzled over the Merchant Shipping Act, with its upwards of 500 clauses, and the Admiralty regulations and diagrams. He honestly tries to understand them, but he cannot, and surely such a rule as that proposed by Captain Curme would meet the dullest comprehension.

Captain CURME: Mr. Harper will bear me out that there are numberless cases where ships have run into each other because they thought it was an *inflexible rule* that when they sight each other they must port their helms.

Commander HEATHCOTE: There is one case in which I think the simple rule might act not beneficially, that is, supposing one vessel sees a red light on her starboard bow, then, according to the rule, the vessel seeing the red light is to port her helm, and the vessel seeing the green light is to starboard her helm. The rule as simply stated just now was, that a red light being seen by a vessel she should port her helm; and a green light being seen by a vessel she should starboard her helm. That is very simple.

Captain CURME: That was an hasty attempt of mine at summarising it; but I did not intend to alter the rule that one ship making out another on her starboard side is to give way, and that the other is to hold on.

Commander HEATHCOTE: Then that is not the rule.

Captain CURME: I confess that is the case, but I ought to have put it in this way. When a ship, by making out another on her own starboard side, is bound by the present law to give way, she shall give way, and when a ship making out another on her port side is entitled to hold on by the law as it is now, she shall hold on; so that my alteration would merely be, that ships making out another in such a direction, that it is incumbent upon them to give way, shall give way, by putting their helms to port if they see the red side-light only; but by putting their helms to starboard if they see both the side-lights, or the green side-light only.

Captain BAKER: You mentioned the case of the "Pacha" and "Erin," in the Straits of Malacca. That was a peculiar case. They made each other out about five miles distant; it was a hazy night, fine weather. They made each other out about half a point on their bow, not more than that, or nearly right a-head. They were steering S.E. by E., and N.W. by W. The "Pacha" was coming N.W. by W., and the captain being, I presume, rather a timid man, put his helm a little a-starboard. The other commander, whom I know very well, had it reported to him that a steamer's light was a-head. He came on deck, and gave the man at the wheel the order, "Just keep that steamer clear on your port bow." "Aye! aye!" In the meantime, the "Pacha" was edging off with a starboard helm; the captain of the "Erin" looking up could not see the light, and he said, "Do keep her clear on the port-bow." He had not the slightest idea that the other steamer would starboard her helm, the rule being to port—there being a rule now that two ships, meeting nearly end on, should port as they approach. The captain did not think for a moment that the other would be starboarding, therefore he did not look at his compass; and the man at the wheel did not tell him the ship had gone off four or

five points, until it became actually a case of contact. As they approached each other, one put his helm hard a-starboard, and the other hard a-port, and they ran into each other. If there are too many rules, the system will become too complicated: it must be either, "port," or "starboard." If you have too many rules, men will get confused. That is my impression from an experience as commander of a steamer for many years. The rule to port appears to me to be a very good one, no doubt, meeting either end on, or nearly end on. I merely mention this, having been perfectly aware of the circumstances of these two ships. It was a peculiar case; I suppose there is scarcely another on record like it. One man was timid; he put his helm a-starboard, and kept edging off a little; the other put his helm a-port, according to the Admiralty regulations.

Captain CURME: There are already two rules, the 13th and 14th, and I only propose to omit indefinite expressions in Article 13, and supplement Article 14 by directions how the giving way is to be performed.

Mr. LACON: Will you allow me to say from what we have heard to-night, and also from what we heard in the two nights' discussion on Captain Heathcote's paper that it more and more convinces me that the great loss of life at sea, and the great destruction of property, arise from preventible causes. I hope that men like Captains Heathcote, Curme, and Colomb, will go on with the agitation of these subjects; and by and bye we shall have a Reform Bill which I believe will be of great advantage to the country and to the public generally. But I believe that the mischief of the existing state of things lies in the want of responsibility. Just now you heard Mr. Gray wishing to repudiate additional responsibility being thrown on the shoulders of the Board of Trade. Mr. Gray says it is ridiculous to make the Board of Trade responsible. We had an instance of a ship that had a hole in her boiler. It was impossible the Board of Trade could know it, they were purposely kept in ignorance of it; yet an Irish jury brought in a verdict of manslaughter against the Board of Trade. It is not at all surprising, therefore, that the Board of Trade should wish to throw the responsibility off their shoulders, and throw it on the shoulders of the proper persons, the owner, and (through the owner) the captain, his mates, and the engineers.

The CHAIRMAN: We may also say of this paper that we are very much obliged to Captain Curme, and also to the gentlemen who have favoured us with their remarks. The more these subjects are agitated, the nearer we shall get to the truth. I think we have pretty nearly come to a conclusion that something is wanting, though we may disagree as to what the exact wording should be. It will, I think, take a little trouble and attention to make out the exact wording which will be required for meeting the various points. I can see that something is wanting; yet, we must always be very careful in making regulations that we do not make that which we shall have to unmake shortly afterwards. Therefore I should like this subject to be well thought over before any alterations are made. We may see an evil, and may make an alteration which we may find afterwards not to be the exact thing. At the same time we are indebted to those gentlemen who have pointed out to us that some alteration is requisite, and also the direction in which that alteration should be made.

Monday Evening, July the 16th.

REAR-ADMIRAL A. P. RYDER in the Chair.

ON "THE LOSS OF LIFE AT SEA."

By WILLIAM STIRLING LACON, Esquire.

THIS being the last evening of the season, I will now that I have received the permission of the Chairman and the meeting, explain to you what may be considered the result of our several deliberations upon the "Loss of Life at Sea," and the various subjects incidental to it.

I shall represent the matter to the Council that the papers and discussions upon them may be brought together in one pamphlet,* that the public and authorities may judge of the value of this Institution, and award the merit where merit is due.

It was after the discussion upon Captain Curme's paper on Monday evening last that I went home and pondered deeply upon what I had heard, and it was that night, from 12 to 3 a.m., that I lay awake during the very time that the "Amazon" and "Osprey" were sinking, and the next morning I carried to the Admiralty a diagram of which that below is a copy.

I said then (twenty-four hours before we received intelligence of the collision) that vessels meeting in that position would, in all probability, come to grief. At the same time I deposited what I considered to be a remedy for the future, which I will presently explain to you.

The present state of the law is not sufficiently explicit, and can be best described by "the rule of the road," which I noticed this week in the "Notes and Queries:"—

> "The rule of the road is a paradox quite
> When sailing your vessel along;
> If you go to the left, you'll be sure to go right,
> If you go to the right, you'll go wrong."

In the enquiry that is about to take place I have the greatest confidence that the honour of all parties will be safe in the hands of those in whose custody it will be placed by law, and that one man may not be acquitted or found guilty at the expense of another, but that if the law is at fault—*the law will be found guilty.*

* The above pamphlet, containing the papers on Loss of Life at Sea, Collisions, Ship's Lights, &c., can be obtained at the Institution, or at Messrs. Mitchell's, Charing Cross. Price 2*s.* 6*d.*—ED.

Diagram deposited at the Admiralty.

Art. 14.—If two ships are crossing each other so as to involve risk of collision, the ship which has the one on the starboard side shall keep out of the way of the other.

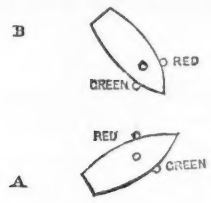
In a letter to Belfast, 1854, their Lordships strongly disapprove of the use of the *port* helm under such circumstances.

Art. 13.—If two ships are meeting end on, or nearly on end, so as to involve risk of collision the helms of both shall be put *to port*, so that each may pass on the port side of the other.

Where A sees B's masthead and green light only, but B sees A's three lights, each vessel should starboard her helm; or B continuing her course, A should starboard and pass astern of B.

Sanctioned by Admiralty Letter, December 11th, 1854.

2nd position.



By both vessels putting their helms to *port* they would pass each other to port, if they are at sufficient distance to clear each other. But they may become, accidentally, so near each other, that doing so —that is, by porting their helms—a collision becomes inevitable. Thus then great caution is required by two vessels crossing each other's courses when in this position, and it is clear they must be guided by circumstances. We believe it is erased from the rules laid down by the Admiralty.*

I differ, in toto, from what has been laid down within the last two or three days by a great authority, that a man-of-war is entitled to follow her own notions and to pirouette about the seas, misleading everybody. Make your laws correct, and the captain of the man-of-war will be as much bound by them as the commonest merchant skipper.

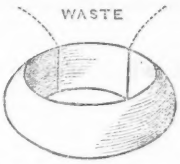
The next thing I would explain to you is, what we have learnt from Captain Colomb's paper, that the law, with respect to ships' lanterns, is very generally departed from, and it appears to me partly to arise from the fact that what you have required from shipowners is useless, and throws an unnecessary expense upon their shoulders. You require from them what common-sense tells you is useless, but make your laws in unison with common-sense, and then punish the slightest infringement of them.

Captain Colomb has told you that the lenses are manufactured in cylinders or circles, and that to cut one for the bright light into twenty points involves a waste of the other twelve; whereas if sixteen points of an arc should be considered sufficient, one cylinder or circle might be cut into two lenses.

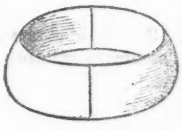
In the same way, for the side or coloured lights, the circle or cylinder should now be cut into two lights only, involving a waste of nearly one-third of the glass, whereas if nearly eight points of an arc should be considered sufficient, one cylinder or circle might be cut into three or perhaps four lenses. This latter may be drawing the thing rather too fine, but it is worthy of consideration. In the suggested alteration of the law, reference is had to this matter because

* "Rules of the Road, or Laws of Passing Vessels." Sold by J. D. Potter, 31, Poultry, Agent for the sale of Admiralty Charts and other publications.—W. S. L.

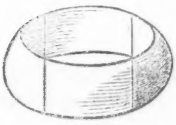
your laws should be practicable, and no departure from them should for one moment be permitted.



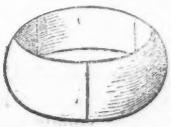
One lense of 20 points.



Two lenses of 16 points.



Four lenses of 8 points.



Three lenses of 10 points.
Vide Capt. Colomb's paper.

Proposed Rules for Steamers meeting at Night.

Sea-going steamers when under weigh should carry—

At the *foremast head* a bright white light so fixed as to show an uniform and unbroken light over an arc of the horizon of *nearly sixteen points of the compass* (the lens being cut into two), so fixed as to throw the light *eight points* on each side of the ship, namely, from right ahead to abeam on either side, and of such a character as to be visible on a dark night with a clear atmosphere, at a distance of at least four miles.

On the *starboard side*, a green light, so constructed as to throw an uniform and unbroken light over an arc of the horizon of nearly *eight points* of the compass, so fixed as to throw the light from *one point on the bow, or one point from the line of keel*, to one point abaft the beam on the starboard side, and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least *two miles*.

On the *port side*, a red light, so constructed as to throw an uniform and unbroken light over an arc of the horizon of nearly *eight points* of the compass, so fixed as to throw the light from *one point on the bow, or one point from the line of keel*, to one point abaft the beam on the port side, and of such a character as to be visible on a dark night, with a clear atmosphere, at a distance of at least *two miles*.

The said red and green lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to block out the coloured lights from one point from the bow, or one point from the line of keel, *on either side*.

All steamers to have their lights in *one fixed relative position.*—*Vide* Captain Heathcote's paper.

Portable lights, auxiliary to fixed lights.—*Vide* Captain Colomb's paper.

Articles 13 and 14 of the steering and sailing rules to be repealed as regards steamers meeting at night.

Rule 1.

If a vessel showing a *bright light only* sees a *bright light only*, she should put her helm to port.

Rule 2.

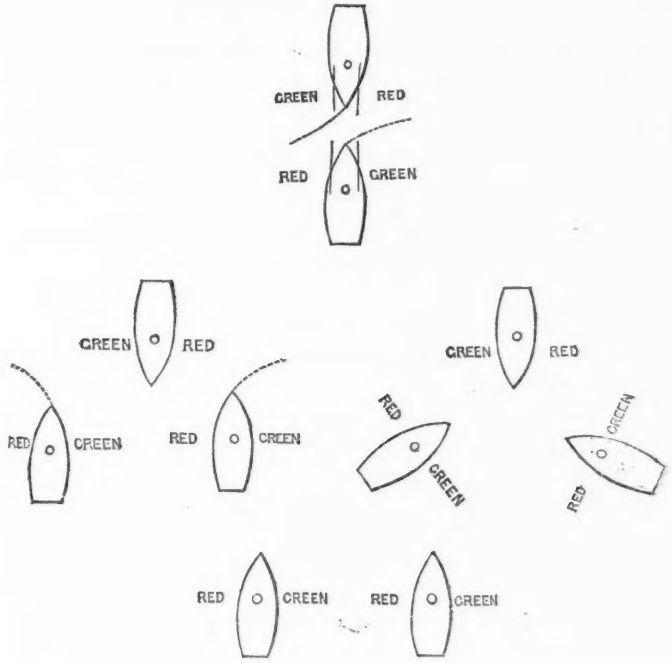
If a vessel shows a *red light* to another which is also showing a *red light*, she should put her helm to *port*, and the approaching vessel, seeing a *red light*, should put her helm to *port*.

If a vessel shows a *green light* to another which is also showing a *green light*, she should put her helm to *starboard*, and the approaching vessel, seeing a *green light*, should put her helm to *starboard*.

Rule 3.

If a vessel shows a *red light* to another which is showing a *green light*, the vessel showing the *red light* should mind her *port* helm and *stand on*.

If a vessel shows a *green light* to another which is showing a *red light*, the vessel showing the *green light* should mind her *starboard helm*, stop *if necessary*, and then port her helm.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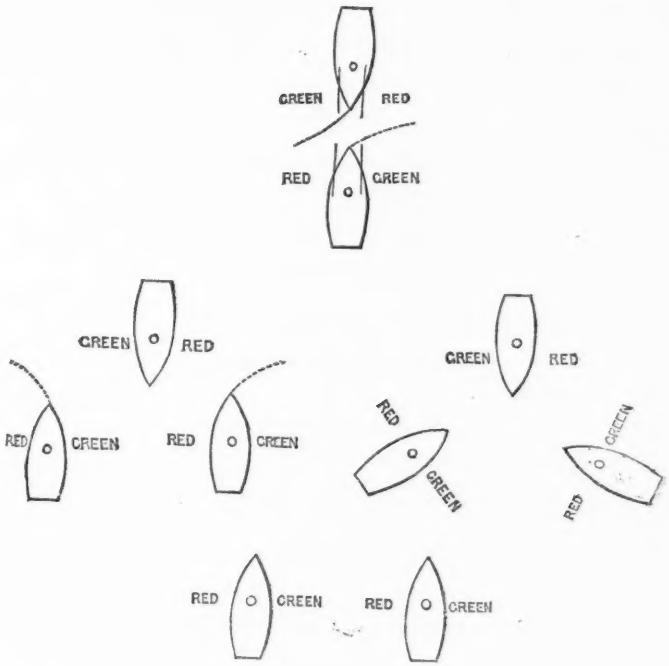
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GREEN

REGULATIONS FOR PREVENTING COLLISIONS AT SEA.

Issued in pursuance of The Merchant Shipping Act Amendment Act, 1862.

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Preliminary.

Art. 1. In the following rules every steam ship which is under sail and not under steam is to be considered a sailing ship; and every steam ship which is under steam, whether under sail or not, is to be considered a ship under steam.

Rules concerning Lights.

Art. 2. The lights mentioned in the following Articles, and no others, shall be carried in all weathers between sunset and sunrise.

Art. 3. Sea-going steam ships when under weigh shall carry:

(*a.*) *At the foremast head*, a bright white light so fixed as to show an uniform and unbroken light over an arc of the horizon of twenty points of the compass, so fixed as to throw the light ten points on each side of the ship, viz., from right a-head to two points abaft the beam on either side, and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least five miles:

(*b.*) *On the starboard side*, a green light so constructed as to show an uniform and unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right a-head to two points abaft the beam on the starboard

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NOTE.—In Article 2 the words *numbered* 3, 4, 5, 6, 7, 8, *and* 9 have been added, after, *the following Articles*, and the words "*between*" and "*and*" have been omitted, and "*from*" and "*to*" substituted by Order in Council, dated January 9th, 1863.—W.S.L.

side, and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles:

(*c.*) *On the port side,* a red light, so constructed as to show an uniform and unbroken light over an arc of the horizon of ten points of the compass, so fixed as to throw the light from right a-head to two points abaft the beam on the port side, and of such a character as to be visible on a dark night with a clear atmosphere at a distance of at least two miles:

(*d.*) The said green and red side lights shall be fitted with inboard screens projecting at least three feet forward from the light, so as to prevent these lights from being seen across the bow.

Art. 4. Steam ships, when towing other ships, shall carry two bright white mast-head lights vertically, in addition to their side lights, so as to distinguish them from other steam ships. Each of these mast-head lights shall be of the same construction and character as the mast-head lights which other steam ships are required to carry.

Art. 5. Sailing ships under weigh or being towed shall carry the same lights as steam ships under weigh, with the exception of the white masthead lights which they shall never carry.

Art. 6. Whenever, as in the case of small vessels during bad weather, the green and red lights cannot be fixed, these lights shall be kept on deck on their respective sides of the vessel ready for instant exhibition, and shall, on the approach of or to other vessels, be exhibited on their respective sides in sufficient time to prevent collision, in such manner as to make them most visible, and so that the green light shall not be seen on the port side, nor the red light on the starboard side.

To make the use of these portable lights more certain and easy, *they* shall each be painted outside with the colour of the light they respectively contain, and shall be provided with suitable screens.

Art. 7. Ships, whether steam ships or sailing ships, when at anchor in roadsteads or fairways, shall between sunrise and sunset exhibit, where it can best be seen, but at a height not exceeding twenty feet above the hull, a white light in a globular lantern of eight inches in diameter, and so constructed as to show a clear, uniform, and unbroken light visible all round the horizon, and at a distance of at least one mile.

Art. 8. Sailing pilot vessels shall not carry the lights required for other sailing vessels, but shall carry a white light at the mast-head visible all round the horizon, and shall also exhibit a flare-up light every fifteen minutes.

Art. 9. Open fishing boats and other open boats shall not be required to carry the side lights required for other vessels; but shall, if they do not carry such lights, carry a lantern having a green slide on the one side and a red slide on the other side; and on the approach of or to other vessels such lantern shall be exhibited in sufficient time to prevent collision, so that the green light shall not be seen on the port side nor the red light on the starboard side.

Fishing vessels and open boats when at anchor, or attached to their nets, and stationary shall exhibit a bright white light.

Fishing vessels and open boats shall, however, not be prevented from using a flare-up in addition if considered expedient.

Rules concerning Fog Signals.

Art. 10. Whenever there is Fog, whether by day or night, the fog signals described below shall be carried and used, and shall be sounded at least every five minutes, viz.:—

(*a.*) Steam ships under weigh shall use a steam whistle placed before the funnel not less than eight feet from the deck.

(*b.*) Sailing ships under weigh shall use a fog horn.

(*c.*) Steam ships and sailing ships when not under weigh shall use a bell.

NOTE.—In Article 6 the words "*the lanterns containing them*" have been substituted for "*they;*" and in Article 7 the words *between sunrise and sunset* have been omitted, by Order in Council dated January 9th, 1863.—W.S.L.

Steering and Sailing Rules.

Art. 11. If two sailing ships are meeting end on, or nearly end on, so as to involve risk of collision, the helms of both shall be put to port, so that each may pass on the port side of the other.

Art. 12. When two sailing ships are crossing so as to involve risk of collision, then if they have the wind on different sides, the ship with the wind on the port side shall keep out of the way of the ship with the wind on the starboard side, except in the case in which the ship with the wind on the port side is close hauled and the other ship free, in which case the latter ship shall keep out of the way; but if they have the wind on the same side, or if one of them has the wind aft, the ship which is to windward shall keep out of the way of the ship which is to leeward.

Art. 13. If two ships under steam are meeting end on, or nearly end on, so as to involve risk of collision, the helms of both shall be put to port, so that each may pass on the port side of the other.

Art. 14. If two ships under steam are crossing so as to involve risk of collision, the ship which has the other on her own starboard side shall keep out of the way of the other.

Art. 15. If two ships, one of which is a sailing ship and the other a steam ship, are proceeding in such directions as to involve risk of collision, the steam ship shall keep out of the way of the sailing ship.

Art. 16. Every steam ship when approaching another ship so as to involve risk of collision, shall slacken her speed, or, if necessary, stop and reverse; and every steam ship shall, when in a fog, go at a moderate speed.

Art. 17. Every vessel overtaking any other vessel shall keep out of the way of the said last-mentioned vessel.

Art. 18. Where, by the above rules one of two ships is to keep out of the way, the other shall keep her course, subject to the qualifications contained in the following Article.

Art. 19. In obeying and construing these rules due regard must be had to all dangers of navigation; and due regard must also be had to any special circumstances which may exist in any particular case rendering a departure from the above rules necessary in order to avoid immediate danger.

Art. 20. Nothing in these rules shall exonerate any ship, or the owner, or master, or crew thereof, from the consequences of any neglect to carry lights or signals, or of any neglect to keep a proper look-out, or of the neglect of any precaution which may be required by the ordinary practice of seamen or by the special circumstances of the case.

DIAGRAMS TO ILLUSTRATE THE USE OF THE LIGHTS CARRIED BY VESSELS AT SEA.

And the manner in which they indicate to the vessel which sees them, the position and description of the vessel that carries them.

When both red and green lights are seen:

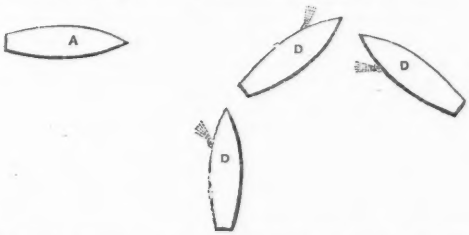
A sees a red and green light a-head;—A knows that a vessel is approaching her on a course directly opposite to her own, as B;

If A sees a white masthead light above the other two, she knows that B is a steam vessel.

When the red, and not the green light, is seen:

A sees a red light a-head or on the bow;—A knows that either,
1, a vessel is approaching her on her port bow, as B;

or, 2, a vessel s crossing in some direction to port, as D D D.

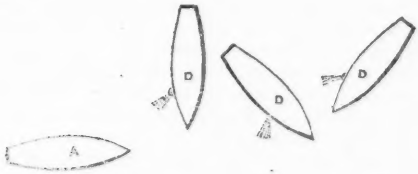


If A sees a white masthead light above the red light, A knows that the vessel is a steam vessel, and is either approaching her in the same direction as B, or is crossing to port in some direction, as D D D.

When the green, and not the red light, is seen:

A sees a green light a-head or on the bow;—A knows that either,
1, a vessel is approaching her on her starboard bow, as B;

or, 2, a vessel is crossing in some direction to starboard, as D D D.



If A sees a white masthead light above the green light. A knows that the vessel is a steam vessel, and is either approaching her in the same direction as B, or is crossing to starboard in some direction, as D D D.

A BRIEF SKETCH OF THE ISLAND OF CEYLON AND A FEW REMARKS ON OUR MILITARY HOLD ON THE ISLAND.

A paper contributed by CAPTAIN J. MEADEN, Ceylon Rifle Regiment, Corresponding Member of Council.

I MUST crave the indulgence of my readers for shortcomings, not only on the plea of my inability to convey in the limits of a short paper anything but a concise idea of the subject under notice, but also that my fingers, being unused to a prolonged acquaintance with pen, ink, and paper, do not take readily to the task before them.

For full and valuable information regarding the island I must refer to "Ceylon," by Sir J. Emerson Tennent, and to the "Ceylon Directory and Handbook," by A. M. Fergusson, Esq., a copy of which last work is in the library of the Institution.

As being more convenient, I will divide the present subject into the following sections:—1st. "General Description of the Island." 2nd. "Population." 3rd. "Military Topography." 4th. "Communications." 5th. "Fortresses and Military Forts." 6th. "Defence of the Coast." And 7th. "Internal Defence."

1. "*General Description of the Island.*"—The island of Ceylon lies off the southern extremity of India, and although so near that vast territory, is under the separate government of the Colonial Office. It lies between the parallels of latitude N. 5° 53′ 0″ and 9° 51′ 0″, and 79° 41′ 40″ and 81° 54′ 50″ longitude E. It is in length 270 miles, and 140 miles broad. The superficial area of the island is 24,700 square miles.

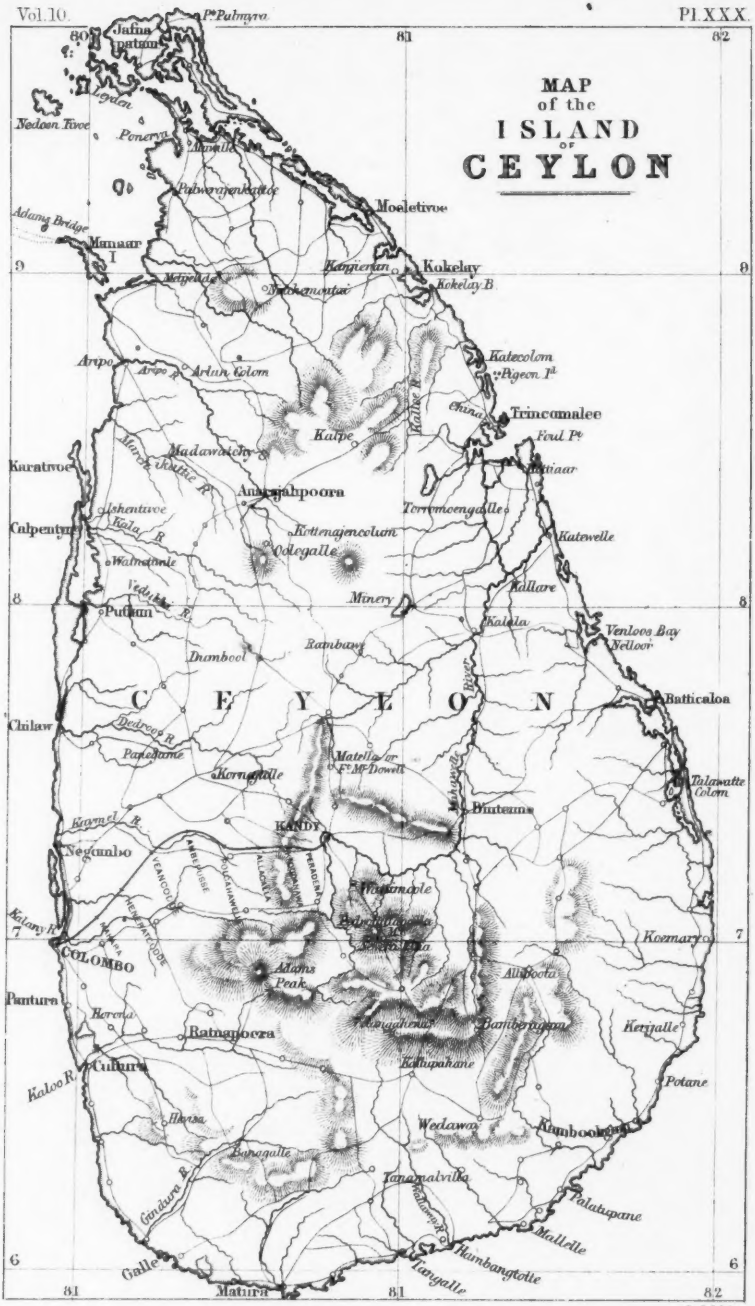
Many readers of my paper who have served in the East know something of Point-de-Galle in Ceylon, the great centre of steam postal communication in the Indian Ocean.

In shape the island is not unlike a ham. The last European rulers of Ceylon evidently thought so, as they called the small fort west of Jaffna "Hamanhiel" (Ham's heel).

For the purposes of civil government, the island is divided into six provinces, viz.:—North, North-Western, Eastern, Central, Western, and Southern. The class and extent of the population, besides the courses of streams and chains of mountains, have had such influence in determining the size of these provinces, that not only are they very irregular in outline, but all vary very much in area.

The largest town and the capital of the island is Colombo, on the western coast; Jaffna, Galle, and Trincomalee, on the coast line are next in size. In the interior Kandy is the largest town. Gampolla, Matella, and Badulla rank next. There are other places of some note on the island, but they may be considered as large villages.

Except at the southern end of the island, the country for miles inland is flat. The mountain zone in the southern half attains its greatest altitude, 8,295 feet, at Pedro talla Galla, 76 miles north of Dondra Head.


MAP
of the
ISLAND
OF
CEYLON
Jafna Patam
Pt. Palmyra
Nedoen Tivoe
Ponerya
Pulwarajenkadoe
Moeletivoe
Adams Bridge
Mannaar
Kokelay
Kokelay B.
Arripo
Arripo R.
Arlun Colom
Katecolom
Pigeon I.
Trincomalee
Kaltie R.
Kaltpe
Fend Pt.
Madawatchy
Karativoe
Anuradahpoora
Terrimoengalle
Calpentyn
Kala R.
Kottenajencolum
Katewelle
Colegalle
Walmatanie
Kallare
Minery
Putlam
Kalela
Venloos Bay
Nelloor
Dumbool
Rambaw
CEYLON
Batticaloa
Chilaw
Pedroos R.
Paneliame
Matelle or Fr. Mc. Dowell
Kornegalle
Talawatte Colom
Bintenna
Kaymel R.
KANDY
Negumbo
Wattemaple
Kalany R.
Kozmary
COLOMBO
Adams Peak
Allipoota
Panturn
Horena
Ratnapoora
Bambergamma
Kerjalle
Kaloo R.
Culture
Kalupahane
Potane
Hansa
Wedawa
Kumbookgam
Barnegalle
Tanamalvilla
Gindura R.
Palatupane
Mailelle
Galle
Matura
Tangalle
Hambangtotte

J. Johnna

The rivers will be noticed in another section.

Generally, the surface of the country is covered with dense shrub jungle. It is only on the higher ranges of the mountain zone that forests of fine trees are to be found.

The seasons are divided into the dry and rainy. From January to May, and from July to October are the dry seasons. In other words, when each monsoon has fairly changed the weather is dry. The monsoons are the north-east and south-west, and, as a general rule, the changes occur during May and October. In May the south-western monsoon sets in, in October the north-east. The change to the latter is accompanied by more rain. The maximum of the temperature at the stations mentioned below was as follows :—

		Minimum.
Trincomalee	90°	
Point-de-Galle	87°	
Jaffna	90°	
Kandy.....	85°	66°
Newera Ellia (the Sanitarium)		36°

The average temperature of Ceylon is considerably lower than the adjoining continent of India.

The average annual mortality amongst the troops serving in Ceylon during the four years, 1861–64, is as follows :—

White troops.....	22·69 per 1,000
Black troops	16·55 per 1,000

The average admissions into hospital for the same period—

White troops 1467·5	per 1,000 per annum.
Black troops 1134·75 per 1,000	,,

The maritime portion of the island has been under British rule since 1796, and the mountain zone since 1815.

The revenue of Ceylon for 1866 is estimated at near one million of pounds. It is recommended that in future £150,000 be set aside yearly for the military protection of the island.

2. "*Population.*"—Of the population of Ceylon only an approximate estimate can be given, there never having been a regular census taken. It is estimated that the several classes of the population number as follows :—

Europeans	3,000
Eurasians	5,000
Other races	6,000
Moors	130,000
Tamils	750,000
Singalese	1,450,000
	2,344,000

Of the Tamils, some 80,000 are reckoned as a floating population. They are natives of southern India, who come over to Ceylon temporarily for the cultivation of the numerous coffee estates. The resident Tamils inhabit the northern extremity of the island, and a strip of the sea-board extending on the east coast down to "Arrogam Bay," and on the west coast to "Pambella." The Singalese race, which may be subdivided into highlanders and lowlanders, inhabit the remainder of the island. The men who inhabit the hills are locally known as Kandians. The Moors are found in small communities scattered over the entire island.

The Tamils, Singalese, and Moors, besides professing different religions, are all *unwarlike* races, and have few sympathies in common. Unless for considerations affecting their pockets (direct taxation, &c., &c.) there is little likelihood of these races combining to attempt the expulsion of their European rulers. On the contrary, the fact of our Government allowing these races to own land, and the prosperity and improved social status of all classes (advantages fully appreciated), afford every reason to the natives for wishing the continuance of British authority.

Considerations of this nature have always great weight in determining the strength of a garrison to be maintained in the midst of a foreign population; still we ought to remember that while the great bulk of that population is grossly ignorant, and only semi-civilized, we ought not to draw the line too fine. Any allowance made, ought to be in favour of a stronger garrison; if there is an error, it will then be on the safe side. To reduce to a minimum the garrison of Ceylon, on the faith of reinforcements being readily obtained from the neighbouring presidency, may answer as long as Madras is at peace; but suppose—and such suppositions must be considered in matters military—that Madras is not in a position to afford aid, how uneasy will be the position (until the arrival of succour) of the 1,200 Europeans scattered singly or in small groups amidst an Asiatic population of *over two millions*, to say nothing of the perils to our prestige. Unfortunately "prestige" has no fixed commercial value, or the power of £ s. d. would make the idea respected.

The garrison of the island—half European, half native troops—is about 2,100 rank and file.

3. "*Military Topography.*"—As previously noticed, the northern and maritime portion of the island is comparatively flat, the northern extremity particularly so. This maritime zone is intersected by numerous streams, few of any magnitude except during the rainy seasons; then the great majority become not only impassable for days together, but by inundating the adjoining country, render the movement of troops impracticable. The alternate flooding and drying of this region gives rise to malarious fevers over the greater portion of its surface. Along the coast a chain of lagoons, or backwaters, is to be found, some of them of great value, from the quantity of salt formed by evaporation. Numerous tanks, mostly in ruins, are scattered over this portion of the island. During the rains these tanks are full of water, and as the sun gradually dries their borders on the water receding at the termination of the rains,

a sensible addition to the malarious influences of the climate is caused.

The mountain zone is very rugged, but the country that lies between it and the southern extremity of the island is less bold; the hills are of lower elevation, and the valleys between of greater breadth. This portion and the western province is more densely populated than the rest of the island, and possesses a greater extent of native rice grounds.

The principal rivers are the Mahavella, Kalany, Kaloo, Gindura, Matura, Wallaway, Pomparipoo, Dedroo, and Maha Oya. Except the first named, the others do not attain any great volume until they leave the mountain zone. In the upper part of their courses they partake of the characteristics of mountain torrents, and are unfordable only in the rains. The Mahavella is at present spanned by three permanent bridges, the furthest being within twelve miles of Kandy; a fourth, the railway bridge, is in course of construction at Peradenia, four miles from Kandy.

The Kalany is crossed near Colombo by a bridge of boats, and also by an iron railway bridge. At Caltura there is a wooden pile bridge across the Kaloo river; the same at Matura. The Gindura is crossed, not far from its mouth, by a bridge of boats. The other streams are crossed in ferry boats. Some minor streams have also regular ferries.

The Kalany, Kaloo, Gindura, and Matura rivers are navigable for some distance from their mouths, and on their banks large flat-bottomed boats, fit for the construction of temporary bridges, are procurable in moderate numbers.

About 150 miles of canals exist, principally in the western province.

4. "*Communications.*"—Roads, the arteries of trade in peace, the principal means which nearly doubles the power of troops in holding possession of a country in war, require special notice, more particularly as Ceylon has good reason to be proud of her network of roads, constructed, as they have all been, within the comparatively brief period our rule. The latest authority, "Summary of Information regarding Ceylon," by A. M. Fergusson, Esq., gives the following:—"Roads metalled, 570 miles; gravelled, 460; ungravelled, 1,360—total miles of road, 2,390, or one mile of road for every ten square miles of extent in the island." The metalled and gravelled roads are kept up with great care and at a considerable expense.

That the local authorities are fully aware of the value of roads and bridges, not only in promoting the prosperity of the country, but for thoroughly opening up the country in order to permit a firmer hold being kept on it, is evidenced by the fact of their devoting more money to this object than can be actually spent.

In a military point of view, the roads may be divided into first and second class. The first class roads are practicable for heavy-wheeled traffic in their entire length, in all weathers; the second class roads, only in dry weather; and the ungravelled portion of this class, even in dry weather, is only fit for light traffic. The second

class roads labour also under the serious disadvantage (as a rule) of not being bridged in their entire length.

The first metalled road, penetrating the mountain zone, was constructed by order of General Sir Edward Barnes, and is the best monument to his sagacity and enlarged mind. It extended from Colombo to Kandy. Subsequent extensions and branches have continued this system to the following limits, all within the mountain zone; viz., Matella, Pangwilla, Hanguranketti, Tildenia; beyond Badulla, Midemahanewera, Dimbolla, and Yattiantotte, besides sundry minor branches. It is difficult to calculate the importance that the first military road, and the system it gave rise to, has been to Ceylon in developing its resources, and opening up a field for the operation of capitalists.

This system of roads in the mountain zone has not only been of great value in a commercial, but it has the still greater merit, in a military point of view, of turning the strong points of the country, in rendering our hold on the hills more secure, and in consolidating our power over the whole zone.

In the maritime districts no regular system has been observed in the tracing of the roads. As a pressing want is felt, it is met by the construction of a road; they are, however, numerous enough for military wants. Taken together, the extent and direction of the whole system of roads show how readily the country can now be effectively controlled by the combined operations of moveable columns. As the extension of the system of roads, and the metalling, and especially the bridging of those of the second class proceeds, the facilities for the movements of troops and supplies will become proportionally greater.

A railway between Colombo and Kandy is in course of construction. The first section, between Colombo and Ambapussie, 34 miles, has been opened. The general direction of this line is parallel with the military road.

For the transport of supplies on the first class roads, native carts are available in large numbers. 13,000 carts are registered as employed in the carrying trade between Colombo and the interior. These carts are too heavy for traffic on the ungravelled roads. In wet weather they would be useless on these lines. A moderate number of pack cattle are procurable in the wilder districts. Both carts and pack cattle are too slow for the march of infantry, and would be mostly useful in the transport of supplies to different depôts.

5. "*Fortresses and Military Forts.*"—There are only three points on the sea coast that are maintained as fortresses, Colombo, Galle, and Trincomalee. At Jaffna and Badulla there is a field fort. All the other small forts on the coast line have been abandoned as the island became more tranquillized, and are fast falling to ruins. Hambantotte still boasts of the only Martello tower in Ceylon. Kandy, Newera Ellia, and Kornegalle are simply military stations.

The fortress of Colombo (the capital) has a good trace, having on the land side three regular fronts, with wet ditches, ravelins, and glacis, all further covered by a lake of some extent. Unfortunately, this lake can be drained by a canal at St. Sebastian, the rocks being screened from the fort guns by a hill. The front next the harbour is weakened

by the proximity of the pettah. Ships of large tonnage have to anchor in an open roadstead, beyond the effective fire of the guns at present mounted on the works of the fortress. A hostile vessel, armed with modern guns, could destroy the shipping and bombard the fortress with almost perfect impunity.

The present strength of the garrison of Colombo is half a battery of artillery, five companies of European, and five companies of native troops.

Galle (or Point-de-Galle) is of nearly the same extent as Colombo. The garrison consists of a handful of gunners, one company of European, and two companies of native troops! This fortress is supposed to protect the only tolerable harbour on the western coast. On the land side are two regular fronts, with a fausse-braie, no ravelins, a ditch (scarcely worth the name), and the rampart exposed to its very foot. Within rifle range are eminences, from which a destructive fire could be poured into the body of the place, the attempt at defilading being insufficient against the curved trajectories of bullets, which can now be discharged with precision from much greater distances than of old. Some shell guns command the entrance of the harbour; but its best defences are the natural obstacles, in the shape of rocks, which obstruct the entrance.

Galle has become a port of great consequence, since the establishment of steam postal communication in the eastern seas, and the extension of the Indian telegraph system to this point. This port is the rendezvous of steamers from the Bay of Bengal, the China seas, and the Australian colonies, and ere long will be that for postal steamers from the Mauritius. This last island is in regular steam communication with the Cape colonies. In Galle harbour may be seen at the same time, French and English steamers, from Calcutta, China, Japan, Australia, Bombay, and Suez, together with large French steam transports, to or from Saigon. A large and increasing number of sailing ships, both laden and in ballast, touch at Galle for telegraphic orders. Galle may thus be fairly considered the great centre of communication in the Indian Ocean.

Trincomalee, with its magnificent harbour, besides being the most secure, is the most convenient central point in the Indian ocean, as a rendezvous for Her Majesty's navy. It has been so since the harbour came into our possession, and the Admiralty have established at this place a naval yard, so as to enable war vessels to refit and re-victual in smooth water. The harbour is land-locked, and the entrance so situated that sailing ships can leave or enter in either monsoon, without the aid of steam tugs.

Two works partially protect the harbour, Fort Frederick on the coast line, and Fort Ostenburg, at the mouth of the harbour. Fort Frederick is distant from Fort Ostenburg about three miles, and is a promontory, enclosed on the land side by a regular front, with an unfinished ravelin, ditch, and glacis. The ravelin is now a shapeless mound of earth. The fort commands the anchorage in Back Bay, and would do the same to the isthmus between the harbour and sea, were the ground clear of houses, &c., &c. The harbour could be thoroughly searched, by long range guns, mounted on the elevation inside the fort.

Fort Ostenburg is built over the entrance of the harbour, on the termination of a range of low hills. The fort is strong enough, but appears too elevated above the water to play a decided part in sealing the mouth of the harbour to an enemy's vessel; the water is deep close to the foot of the cliff, and there are no depression gun-carriages in this fort. The entrance to the harbour is three cables in width; the greatest depth of water at the entrance is 33 fathoms; rise and fall of the tide about 2 feet. Like Galle, Trincomalee is in telegraphic communication with the entire coast line of India. The garrison of Trincomalee is made up of about one-third of a battery of artillery, two companies of European, and two companies of native troops.

All the fortresses, Colombo, Galle, and Trincomalee, are not only deficient in guns to arm them properly, but are unprovided with casemates, bomb-proofs, or long-range guns. Not that this matters very much, for of late the entire military force stationed in Ceylon is inadequate to defend any one of these fortresses in the event of a siege, supposing the walls and outworks, in their present dilapidated state, were worth the sacrifice. The fortresses are safe from a *coup-de-main*, but having said that much we have said all.

Jaffna and Badulla are field forts, each occupied by a company of native troops.

Kandy is the principal military and civil station in the mountain region. The town and station are encircled by chains of hills. The military force there consists of two companies of Europeans, three companies of natives, and a handful of gunners.

Newera Ellia, the sanitarium, is situated amongst the highest mountains in Ceylon. The station is on a narrow plain, 6,000 feet above the level of the sea. The climate is pronounced good, so far as preventing the contraction of tropical disease; but not fitted for the cure of patients already affected. Invalids are, however, sent to this station.

Kornegalle and Hambantotte are small stations, maintained for the convenience of the civil government. A few native soldiers are stationed at each place, to protect the Government treasure chests.

6. "*Defence of the Sea Coasts.*"—This section, except for the existence of the three fortresses before named, might be abbreviated into the words "totally defenceless." To a certain extent the monsoon is a defence to the coast, which alternately becomes a lee-shore; but until the monsoon changes, the other coast has not even this slight protection. Until a total change is made in the military system, the coasts must be practically left to be defended by the Royal Navy, keeping the seas clear of hostile ships.

The garrisons of the fortresses are too weak to allow of any considerable force being detached for more than a day's march, and even in such a case could do but little to prevent a landing under cover of ships' guns, there being no modern guns of position to accompany and aid the efforts of infantry.

When operating for the capture of Colombo and Trincomalee, the British troops landed unopposed at Negombo, and at Cutcheville.

As the outbreak of a war with a maritime nation would find Ceylon depending for external protection on Her Majesty's Navy, the necessity for a convenient and secure rendezvous in the island for the ships of that Navy ought to be considered and provided for before-hand. Trincomalee is the only land-locked harbour in Ceylon, and not only in Ceylon, but on the whole line of the Indian coast, from Bombay to Calcutta, a distance of nearly 2,000 miles. It is also in telegraphic communication with Galle, Colombo, and Manaar, and with different points on the Indian coast. The harbour is thus peculiarly fitted, from its central position, for the rendezvous of our cruizers. Here they could refit, re-victual, and be in the most favourable position for prompt despatch to any threatened point. There is already a naval yard at this station, and with some addition to the strength of the works and garrison it would always constitute a depôt, safe from the desultory attacks of an enemy. Being, in fact, the naval base in the Indian Ocean, the security of this harbour ought to be placed beyond a doubt.

Trincomalee being only 250 miles from Madras (little more than one day's steaming) would also be the base, from which reinforcements would start for the interior, or west coast of Ceylon. Hence it has now become a military necessity, that the road between Trincomalee and Kandy, with the branch from Dambool through Kornegalle to the railway, should be bridged, if not metalled.

To object on the score of the unhealthiness of the adjacent country is absurd. If listened to, a similar objection would have been fatal to the opening of the military road, and the railway between Colombo and Kandy. There is no just reason for thinking that the money spent on these roads would be lost. If Trincomalee is benefited commercially, she must share that benefit with the rest of Ceylon. To isolate, and neglect the natural advantages of a place, and then point to the certain results of such a policy as an excuse for continued neglect, seems an odd proceeding. Perhaps there are cogent, though occult reasons why Trincomalee should not have the chance of contributing to the prosperity and importance of Ceylon. To outsiders, it seems discreditable to the age, and a blot on our rule, that one of nature's most magnificent gifts should be still in pretty much the same state as when we took possession.

The garrison of Trincomalee ought not only to be strong enough to secure the harbour, but be able to prevent a small force establishing itself within easy reach of the harbour.

7. "*Internal Defence.*"—The population of Ceylon being composed of many races, to a great extent intermingled, and all of peaceful habits, there is no very great danger of their combining to expel the ruling race. But as the bulk of the native races is grossly ignorant, and easily imposed upon, there is always the risk of partial efforts being made to resist the authority of the local government. Any absurd reasons, backed by a show of probability, would be enough to cause a rising. Being Asiatics, we could not, in an event of this kind, afford to suffer a check, much less a repulse, at their hands.

Wherever troops are stationed they ought to be in sufficient force to

send out, when required, a moveable column, strong enough to bear down all opposition; in fact, to put successful opposition out of the question. The fact of such a power being available at a moment's notice is the best guarantee for the peace of the country, and is, in the long run, the most economical policy.

If, unhappily, it should be necessary to use the military power in suppressing any disturbance, we ought to be able to act with a firm, determined hand, and crush the attempt promptly. Half-measures with Asiatics will never do. They only interpret them as signs of weakness, and deride the notion of their proceeding from motives of humanity on our part. They know no such feeling themselves, and cannot credit their existence in others. Any display of them on our part would encourage and extend opposition.

Small outposts are to be deprecated. They are truly indeed so many sources of weakness, and ought to be all withdrawn. Even with the concentration of the force now on the island, a poor show will be made of the power by which we ensure the possession of the land. With all due deference to the higher authorities, the force seems to me too small for even so peaceable a place as Ceylon.

An ignorant native, whose ideas of the world are limited to a few miles of country in his neighbourhood, varied by an annual visit to the nearest court-house about an interminable land-suit, can be scarcely expected to realise the abstract idea of the power of the British empire; but an occasional sight of the armed body that upholds that power is a fact easily understood by the dullest intellect. It is a pity if an impression of this nature should be endangered by beholding only a handful of men. Instead of a wholesome dread, contempt for the military resources of the empire might be engendered. As long as peace prevails, all will be well, but should the peace of the land be seriously endangered, our position in Ceylon, until succour arrives, might not be a pleasant one.

With such a weak garrison as that at present in Ceylon, it is all the more necessary that every part of the island should be connected with good roads, and these well bridged, so as to allow of moveable columns reaching a threatened point with the utmost celerity, and of suppressing vigorously any insipient attempt at opposition on the part of the native races. Of roads there are fortunately enough, but they require bridges at certain points to complete the system necessary for the effective control of the country. Stone and iron bridges are preferable, as they are not readily destroyed, except by the scientific application of the explosive agency of gunpowder.

In the event of a general guerilla warfare, for which the nature of the country and jungle presents facilities, nothing but the persistent and combined action of moveable columns would avail; and to insure the pacification of the island additional forts on the commanding points, both of the country and of the communications, would have also to be formed, to serve not only in overawing the country, but as depôts and points *d'appui* for the operations of moveable columns. That such a system of fortified posts existed in former years is evident from the ruins of field-works to be found in various

places. In a warfare of this kind we must be prepared for serious mortality, which would rapidly thin the ranks of effective men. Operating with moveable columns of infantry, as the nature of the country would compel us to do, must necessarily entail on the men employed in the field great hardships and exposure; the results of which, in this warm, moist climate, would soon be shown in the contraction of malarious fevers and dysentery.

Under present circumstances a concentration of the troops at Kandy and Newera Ellia would allow (in the event of a partial rising of the natives) of moveable columns being sent in any direction within the mountain region. Columns moving in this zone would not derive direct benefit from the influence of columns moving in the maritime zone, there being so few practicable passes leading to the maritime region. For instance, there is not a practicable pass in the range of mountains extending from the Kalany river to Happootille, or in the range extending from Lag-galla to Midemaha-Newera.

The maritime zone would have to be controlled by columns from the fortresses and ports on the sea-board, viz., Colombo, Galle, Trincomalee, and Jaffna. These places are so few in number, and at such distances from each other, that unless re-victualled from some intervening point on the sea-shore, a moveable column would have to retrace its steps before coming into communication with the column from the next station.

Moveable columns operating in this island would have to be very lightly equipped. Each man to carry two days' provisions; a supply for four more days to be carried by coolies.

The groups of coffee estates on the mountain region are favourably placed for impeding the communications of the natives with the maritime zone. The arming of the European planters and a select number of their Tamil labourers would, in this respect, be found an effective measure. At the principal military stations the arming of the European and Eurasian residents as town guards would set free a number of men for field duty.

In the event of a general rise amongst the native races the present garrison of Ceylon would be only equal to the performance of about one-third of the work which would necessarily fall upon it, and must run the risk of being speedily placed on the defensive until the arrival of reinforcements from India or some more distant point.

At present there is peace and tranquillity in the land, but our arrangements ought nevertheless to be made so as to be ready for the contingency of tumult and disorder.

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